SCIENTIFIC AMERICAN
No. SUPPLEMENT 650

Scientific American Supplement, Vol. XXV., No. 650.
Scientific American, established 1845.

NEW YORK, JUNE 16, 1888.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE NEW PORT OF HAVRE.

THE Bellot basin, which bears the number 9 in the series of docks of Havre, is constructed upon made land to the south of Tancarville Canal. We borrow a description of it from an article recently published by Government Engineer H. Desprez.

The basin is bounded on the south side by a masonry dike 3,280 feet in length and a stockade 1,790 feet in extent. Its total length, including that of the entrance lock, is 3,762 feet. It is divided into two floating docks, called the east and west, which are of unequal length, but of a uniform width of 720 feet. The area of the dock is 253,460 square yards.

The entrance lock, the axis of which is in the prolongation of that of the Transatlantic lock, is 98 feet in width. It is provided with ebb gates that permit of isolating the Bellot from the Eure dock. The leaves of this gate, which are of rolled iron, are 54 feet in width and 36 in height. The system of construction adopted includes vertical posts that support the external edge and that rest upon two horizontal cross pieces placed, one of them, at the upper part, and the other at the lower part of the leaf. This latter comprises a series of air and water chambers below and water chambers above. The respective volumes of the leaves permit of reducing the weight of each upon its hinges from 155 to 25 tons.

The sluiceway between the two docks is 98 feet in width. Two revolving bridges, of a single span, and having two wagon roads, cross the entrance lock and the central sluice. The extent of the wharf walls is 8,708 feet, of which 7 806 are utilizable for navigation. The platforms are 270 feet in width at the north and 375 at the south, including the space reserved for the service roads and railways. Their total area exceeds two million square feet.

A water inlet closed by two metallic gates each weighing 11,100 pounds is formed in the southern wharf, in order to fill the dock at rising tide and diminish the currents between the jetties and in the locks.

The dike in the offing is prolonged toward the east by the stockade of which we have spoken, and which is to allow of the construction, behind the dock, of a vast platform of an area of over a million square feet, to serve as a location for a large maritime station connected with the tracks of the Railway of the West.

Great difficulties have been encountered in the construction of the Bellot basin in consequence of its execution on a shore exposed to violent tempests. The work has been done partly by means of pumping performed behind an insubmergible boat, and partly by compressed air. Among the first of the structures figures the dike in the offing, which is founded upon beton that was run into an excavation made on the shore of the mouth of the Eure to a depth of five feet beneath the level of the earth, the excavation being kept dry by pumping at every rise of the tide. How difficult this work was will be appreciated when it is known that after various fruitless tentatives to effect the pumping by means of centrifugal pumps established upon the neighboring platform, it became necessary to put the machines on the shore at every low tide, and then hoist them up and put them under shelter on the platform during flood tide, thus reducing the time of effective work to two hours per tide.

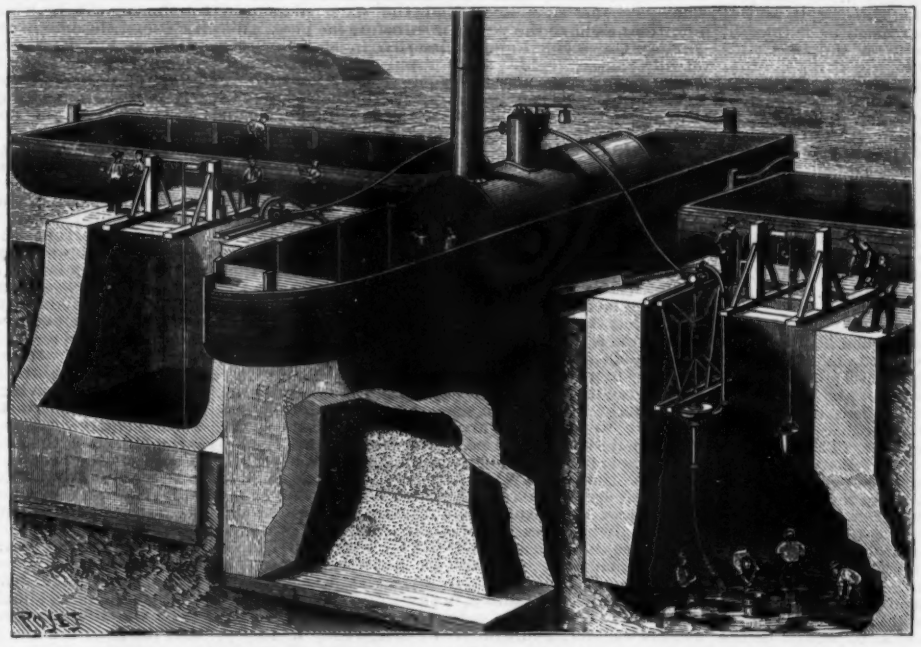


FIG. 1.—SINKING BLOCKS OF BETON IN THE PORT OF HAVRE.

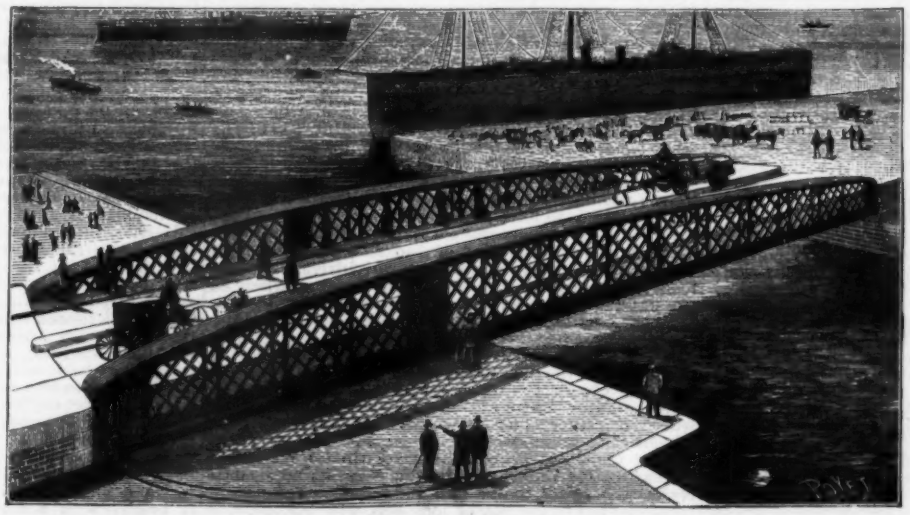


FIG. 2.—REVOLVING BRIDGE.

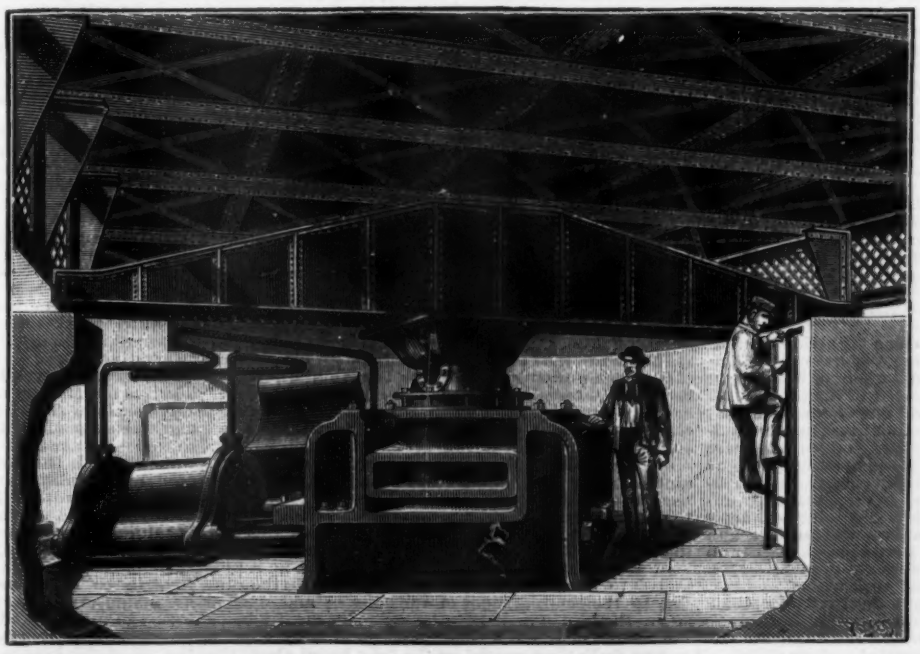


FIG. 3.—APPARATUS FOR MANEUVERING THE BRIDGE.

Another operation no less delicate was the sinking of the foundation blocks of the wharves of the western floating dock. The blocks used for the substructure of the wharf walls were 33 feet in length by 22 feet in width, and had a central aperture to allow of the removal of the excavated material, and thus determine the sinking of the blocks themselves. The masonry for each of them, 14 feet in height, was laid upon a simple platform of planks placed upon the shore. After allowing thirty days for setting, the earth was excavated in the interior so as to sink the block into the ground for its entire height. Then the masonry was laid to a further height of 10½ feet, and after another rest of twenty days, the sinking was resumed and completed. The central aperture was then filled in with beton.

The sinking of the blocks necessitated pumping, which was performed at first by Letestu pumps worked by hand; but, for the second period of sinking, it became necessary to have recourse to a special installation that permitted of moving the pump and its motor, in order to follow the progress of the work. To this effect there were used small centrifugal pumps with vertical axis driven by three-cylinder Brotherhood engines. The pump and motor were established upon a wooden framework in the interior of the well, and remained in the latter permanently during the entire operation. A barge moored between two of the blocks, and carrying a boiler, furnished steam to two engines (Fig. 1). With this method of working, great rapidity was attained in pumping out each block. The excavated material was drawn up in buckets to the top of the block, put into a lighter, and carried to the earth heap.

There were 87 blocks sunk by this process, representing 1,575,000 cubic feet, at the rate of 106 days per block, inclusive of stoppages to let the cement set. The work was regular, and the blocks were kept in a satisfactory position.

While the dike was in process of construction, the Bellot basin walls and the western wall of the western floating dock were undertaken by means of pumping in an excavation made in the center of the platform adjacent to the Eure dock. The earthwork of the western floating dock and a portion of the walls were executed in dryness after a portion of the dike had been finished and a dam separating the two floating docks had been constructed. The wing walls of the Bellot dock, and the demolition of the wharf wall of the Eure dock, were executed by means of a caisson and compressed air.

The bridges, gates, sluice valves, and capstans of the docks and drains are all maneuvered by hydraulic power. We shall give some details in regard to the spe-

cial apparatus used in maneuvering the revolving bridges. One of these, shown in Fig. 2, is 174 feet in length and 23 in width. It has two wagon roads, and is formed of lattice girders 7 feet in height at the extremities and 13 feet to the right of the pivot. It is so calculated as to permit of the passage over the railway of the heaviest locomotives of the Company of the West.

The two trusses rest upon a cross girder provided with a pivot which revolves in a cylinder whose base rests upon a metallic wedge. This latter, actuated directly by a hydraulic press, permits of giving a vertical motion to the cylinder, and consequently of lifting the entire bridge. Rotation is effected through the action of two funicular apparatus. In order to facilitate this motion and avoid friction between the metallic surfaces in contact, the cylinder is provided at its upper part with a stuffing box forming a tight joint between it and the pivot. The introduction of compressed water into shallow grooves formed in the surfaces in contact permits of relieving the bridge without lifting it, and of effecting the rotation on the water itself.

When locked, the bridge rests upon supports situated upon the wharf walls. During the lifting motion, it swings around a half cylinder fixed beneath the girder and engaging in a cavity at the upper part of the pivot. During its rotation it rests upon its pivot and upon two friction rollers at each extremity.

The diameter of the pivot, which supports a weight of 370 tons, is three feet. The press that actuates the wedge exerts a stress of 180 tons in pushing and 145 in pulling.

The lifting of each bridge requires an output of 150 gallons of water, the lowering takes 95 gallons, and the rotation 38 gallons, when simple power is used, but 73 gallons when the maximum power is employed. The total output is therefore 285 or 335 gallons. The maneuvering takes two minutes.

The construction of the Bellot basin, which was begun at the close of 1880, was finished at the beginning of 1886. It cost, inclusive of the metallic work and the hydraulic apparatus, $4,120,000; but to this sum must be added the expenses of the plant necessary to operate the basin. This includes sheds, loading and unloading apparatus, and the line of tracks connected with those of the Railway of the West. The two first, confided to the Havre Chamber of Commerce, are now nearly finished. The sheds are so constructed as to diminish, in as large a measure as possible, the number of supports. The type devised by Mr. Delachanal to this effect is most satisfactory, both as regards arrangement and rational utilization of materials.

The loading and unloading apparatus are to comprise 38 movable hydraulic cranes and 16 windlasses, which will permit of handling nearly 1,200,000 tons of merchandise a year. The cranes are of double power, and their frames are so established as to permit of the passage of cars and locomotives.

The dock is provided with groups of tracks laid parallel with the edge of the northern and southern wharves of the two floating docks, and a group designed for the sorting out of cars and the making up of trains. But there is reason to suspect that ulterior development of the traffic will necessitate the establishment of a special maritime station connected directly with the Graville station, so that the trains will have no revolving bridge to cross, and will pass over curves of large radius only.

Such are the arrangements adopted for the Bellot basin, which is destined to become in a short time the principal center of traffic of the port of Havre.

The plans for the basin were got up by Messrs. Bellot & Renaud, and the work was done under the direction, successively, of Messrs. Bellot, De Rochemont, Widmer, and Desprez, of the government corps of engineers.—*La Nature.*

SIBLEY COLLEGE LECTURES.—1887-88.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

V.—THE CHALK AGE OF MECHANICAL ENGINEERING.

By J. F. HOLLOWAY, of New York City.

IT was said of a celebrated temperance lecturer, that his success was largely due to the fact that in his travels about the country, he had with him a man whose whole life had been spent in the indulgence of habits just the reverse of those he advocated, and who by thus doing the things he ought not to have done, and leaving undone the things he ought to have done, became to be, and indeed was exhibited as a "*frightful example.*" I speak to those to-day whose good fortune it is to have been born at a time when it is possible to avail themselves of the advantages of college education, of study in technical institutes, and of practice in schools of manual training. In addition to the aid of teachers, the surroundings of libraries, laboratories and workshops, you have the privilege of listening to lectures given by cultured men renowned in science and art.

As a background to this bright scene, it was needed that there should come before you one who, never having had any of these opportunities, one who wanting in those graces and accomplishments that come or should come from a collegiate training, and who should be in fact a "frightful example" of those whose knowledge at best is more of the practical than of the theoretical kind.

Now, do not let us start out with a misunderstanding between us. Do not for a moment believe that I undervalue education, be it acquired where or how it may be. I have all my life felt the need of it, and have always known how much it would have helped me, had I been privileged, as you are, to find in such surroundings such valuable aid as you must. And yet, are there not some compensations which serve to even up all our lives? The dweller amid the hills, whose rough pathway lies onward and upward, ever surrounded by difficulties and dangers, as he climbs and toils, he is by a beneficent Creator endowed with a will to dare and with a strength to accomplish that which a dweller on the plain has no need for, and does not possess.

It is said there is no royal road to learning, and perhaps there never will be one, but the road over which the young man desiring to become an engineer travels to-day is a far plainer and easier one than the one over which his predecessors struggled and stumbled.

It has been well said of the present age that, so far as it concerns engineering, at least, it might well be called the "blue print age."

The age of which I speak might equally well be called the "chalk age." In other words, it will be my mission at this time to speak to you of the old time millwright, machinist, and engineer as I remember them at the time when I first began to learn something of the art of working iron. I trust the picture I may present will not be without interest and some benefit to you. It will be the picture of a gone by age, a picture of scenes you will never look upon except in imagination.

As I have walked through your well appointed workshops, your well lighted and convenient drawing rooms, have looked into your well supplied libraries and laboratory, have listened to the instruction given by teachers and lecturers each skilled in some particular science or process, there has come back to me the memory as to what were the surroundings, what the opportunities, of young men who, starting at the time of which I have spoken of, had the same aims and ambitions as have the young men before me now. We will lay the scene I am to describe in some remote inland village, beside some rapid running stream, whose swift waters afford the power used for turning wheels, which as yet had not been harnessed to the then newly talked of, but as yet not much used, steam engine.

Our hero will be a country boy who early began to show signs of ingenuity and a taste for mechanical pursuits. As usual, his first attempt in engineering begins in whittling a pine windmill, which is tacked on the ridge pole of his father's barn, where it serves to show not only the direction of the wind and its force, but as well the bent of his thoughts and desires.

Next we find that he has built across the brook that flows near by a dam, whose pent-up waters turn the wheels he has built in imitation of those he has so often watched at the saw mill.

Later on, a rudely built pump, actuated by the water wheel, adds a new triumph to his skill, as it flings its tiny stream up into the sunlight.

This may seem a crude and unpropitious beginning in the study of so grand a science as is engineering, but I venture to say there are eminent engineers living whose well planned and ponderous engines are the admiration of all who behold them, who, in the well earned success of their later years find no such joy as came to them long ago, when, as barefooted boys, sitting in the sunshine of early spring, on the side of the brook, nursing their knees under their chin, they watched with throbbing heart their little wheels go round, and planned and yearned for further and greater triumphs. Borrowing of the carpenter an auger and a drawing knife, and finding in the wood shed a hatchet and a saw, in winter he makes his own sleds, in summer his wagons; and while their design may be faulty, their workmanship rough, the ingenuity shown by which unsuited things are made to perform needed results shows a study of the situation truly commendable.

Sandwiched into the years as they go by are more or less of school days, in which the branches of a common education are learned. In the course of time there came to be held a family council, the subject of which is our boy; and where, in spite of what may have been the hopes, desires, and ambitions of the other members of the family concerning him, all agree that it will be useless to try to make of him a doctor, lawyer, merchant, or minister, as he is evidently bound to be a machinist and an engineer. So plans are made by which he is to have a place as an apprentice in the only foundry and machine shop the village affords. Having heard something of the steam engine, and having read of its having been used to drive mills and boats, our hero dreams of the time coming when he can handle a steam engine, to start and stop it at will.

To the poet there come dreams of some fair Arcadia, some paradise regained, some spot where glowing colors greet the enraptured sight, where the fragrance of flowers loads the air with perfume, and where sweet melodies charm the listener into raptures of repose. The navigator has in his mind's eye undiscovered isles whose beauty and solitude woo him onward. The adventurous miner, worn and weary, lies himself down to sleep amid the rugged canons of the far West, and in his dreams there opens in the ragged and seamed rocks that tower above him hidden veins of untold treasure; but to the boy of long ago, who worked, and wished to be an engineer, there came no dreams more delightful, no hopes more pleasing, than of that day when he should hold beneath his grasp to start, to check, or to command some ponderous engine or grand machine. Deem it not idle to thus dream, and hope, and speculate of the future, for had not our hero had some such visions to cheer him on, he would oft have been far more discouraged than he was, as he stumbled and tripped along the rough road he had chosen to walk in. We next find him at the open door of the village foundry, where he is met by the boss, who, taking him into a little den behind the cupola, gives him a stump of a broken file, and shows him how to rub off the sand from the newly made castings. To his kit of tools there soon is added a lump of a hammer and a stump of a chisel. With these he is further taught how to chip off the bunches and ragged edges the unskillful moulder had made, and the runners and gates he had left on. To those who have done this for the first time, I need not say that many, far too many of the lumpy hammer blows missed the stumpy chisel, but did not miss the tender hand that held it. It was at such times that the pain of self-inflicted blows, added to the cheerless surroundings, made our apprentice boy to almost wish that he had chosen to be a minister instead; but a glimpse, even through tears, of that glorious vision of the future made him to clinch his teeth together, wrap a rag around the bruised and bleeding hand, and try it again. After awhile some kind hearted journeyman, seeing his bleeding hand and remembering his own beginning, tells him to go up in the pattern shop and put some shellac varnish on it, which he does, and afterward goes about with a feeling that if he has not yet learned the trade, he has at least learned a new wrinkle. After awhile he is promoted to help wheel scrap and pig iron up the runway to the charging floor of the cupola; and on days when the heat promises to be extra heavy, he helps the melter charge the coke and iron into the cupola, and to chalk their weight on the tally board above the scales as they go in.

Later on, he makes friends with the moulder, by riddling his sand for him or by clay-washing his "gagers," and he thus gets some insight into the art of filling and ramming sand in a flask. At noontime he gets a little flask in the corner, and tries to make a mould of some fancy piece of ironmongery. In my time, the favorite pattern, the *piece de resistance*, was a flat-iron holder; it took but little iron to make, had an ornamental look, and was easily carried home as a trophy.

Here he works away by himself, copying, as he thinks, all the operations of the moulder, and when the flasks are being poured off, he importunes his friend the moulder to pour his flask also; which he does, with a quiet smile, the meaning whereof was at the time unknown. Our embryo moulder and engineer can scarcely wait for the gate to solidify, so impatient is he to see the result of his labor; but, when he lifts off the cope, he finds beneath the mould all right, but no iron in it—he had forgotten to cut a runner from the gate to the mould, by which to let the iron flow into it. His friend the moulder well knew that he had neglected to do so, but he thought the best way to have him remember to do it afterward was to let him make a failure of his first attempt.

It may seem a strange thing that a boy wishing to be a machinist and an engineer should begin in the foundry, but so it was in the "chalk age" of which I speak. After working about the foundry until he could mould grate bars, sleigh shoes, and plow points, and until another new boy had come to take his place in cleaning castings, he was promoted to striking in the blacksmith shop.

Of the misfortunes that befell him there, while learning the art of working wrought iron, I could fill far more time than is now at my disposal.

As you will never again see the old time apprentice boy, who wanted to be a mechanical engineer, so no more will you ever see the old time smith shop, in which he passed a considerable portion of his time, and through which he traveled on this, as he then thought, by no means royal road to learning.

No swiftly revolving fan made "music in the air" in that shop; but instead, a wheezing bellows, whose wrinkled leathern sides puffed out and shrunk in with every stroke of the bellows pole, gave breath to the flame upon the hearth. When an extra heavy heat was to be made, or a weld taken, a heavy stone was laid upon its floating top, which added fierceness to the blast, and labor to the sweating youth at the pole. The art with which the skilled smith heaps high the coals above the tuyere, sprinkling their outer surface with water in order to make beneath it a hollow fire whose blazing roof should reflect down on to the iron beneath the inclosed heat, should be seen, not told.

His watchful eye peers into each crevice, to see to it that the heat is made uniform, and that no burning of exposed edges takes place. Now and then he dashes in a little clean sand to make a flux that shall protect from oxidation its more exposed parts.

Ranged in front of the anvil are the three or four extra strikers called in for the occasion; and who, with upraised sledges poised in the air, await the coming heat. Now from out the roaring fire the white hot iron comes, dripping with melted slag, and about which there gleams up a halo of fiery scintillations that lights up the dingy shop with an unwonted cheerfulness. "Now," cries the smith, and the leading sledge falls on the plastic iron, followed one after another by the others, until under the tuneful measure of their falling strokes the yielding metal is slowly and steadily beaten into forms of usefulness and beauty.

Here, as in the foundry, our hero is adding to his stock of useful information. Watching his opportunity, he tries his skill in shaping a piece of iron, and with the usual experience of all who first essay that apparently simple operation, he finds that every time he lays the heated iron upon the anvil, and hits it with the hammer, it somehow twists from out the tongs, flies past his head, and lands across the shop. Yet every time he starts out to hunt up that lively iron, there comes to him an idea that perhaps he had failed to hold it level on the anvil, until, with frequent dodging and frequent chasing, he finds that the apparently easy thing of holding a piece of iron in a pair of tongs while pounding it is an art. Soon he learns how to heat and shape a steel cold chisel, and much delight it is, when finished, to heat and dip it in the water, rub it bright with a bit of sandstone, and watch with nervous anxiety the glowing colors of each varying temper, as they chase each other toward their vanishing point. If in his haste he plunges the steel back into the water too soon, and leaves it so hard that it breaks, or if he neglects the cooling too long, and his chisel is made soft and worthless, with each failure there comes to him, and to remain with him, an education which practice alone can bring, and practice alone perfect.

The drawings furnished the smith in those days were of varied styles. Sometimes the object wanted was somewhat crudely drawn in the dirt floor of the shop, by the toe of the master's boot. If it was something *very* particular, it was chalked out on the back of the door, or on the top of the bellows, accompanied with a verbal description, aided by a thick thumb sliding up and down a well worn rule.

Having glanced at some of the knowledge and experience that came to our hero through the foundry and smith shop, all of which he found of great value in after life, we must hasten on to the senior years of his study, which finally culminated in his graduation from the machine shop.

I have, in a hurried and imperfect manner, tried to describe the foundry and the smith shop of the "chalk age," but how shall I be able to bring to your view the machine shop of that gone by period—a shop which I so well remember, but which you will never see? As I walk through the steam heated, electric lighted, frescoed and varnished machine shop of to-day, whose swept and garnished floor gives no hint of litter or of labor, I have to pause and close my eyes until memory brings back the picture of the low, dingy, ill-lighted, worse heated, and scantily furnished machine shop of the "chalk age" and of my youth—shops then to be found all over the country, but gone now, and forgotten; shops in which the boys of long ago worked, and, unaided, wrestled with difficult problems, and from out of which there came some of the ablest thinkers as well as the most successful engineers of to-day. Were I speaking to the older members

of a profession of which you are standing on the threshold, I could, I am sure, even with my imperfect description, recall to them memories of this gone-by, but not forgotten, epoch of their lives.

I need not describe to you the changes that have come to the exterior of the modern machine shop; you see them everywhere with their storied walls rising high in the air, with railway tracks running beside them into well arranged yards, where giant cranes lift with outstretched arms ponderous beams and bed plates, finely finished engines, and other massive machinery with celerity and ease. If you do but look closely, you see also the little lawn beside the door, where in the early spring time budding blossoms grace its border; and in the summer, nodding rose bushes add beauty to the scene and a pleasing odor to the air. It was not thus in the "chalk age."

Accustomed as are those before me to see and to use the elegant and burnished machine tools of to-day, in which each curve in the leg has been the study of an artist, each screw and bolt modeled after the most approved scientific formula, where the cross feeds, the disengaging gears, the stop, as well as the go-ahead motions, have been by one maker taken from another, and altered and changed beyond the recognition of its author, until, like the bones of the pauper, it is something "nobody owns."

I can perhaps convey some idea of what the old time machine shop had, by naming some of the many things it did not have. While it did have, as you will infer, a foundry at one end and a smith shop at the other, and between them little else than smoke and grit, fortunately the latter got so well ground into the apprentice boys of those days that it stuck to them all their lives, and served to help them out of many a difficulty.

There were no planers there, no slotters or shapers, no boring mills; and all we boys knew of their existence were tales told us by bibulous tramp machinists, who, wandering out into the then far West, filled us with wonder as we sat about the stove at noontime and listened to the tales they told of the big tools they had worked on at Matty Baldwin's, in the Allaire, the Secor, or Novelty works, or at West Point. But not alone were all these wanting in the old time shop, but as well were twist drills, except of the home made pattern, screw cutting machines, relieved taps, etc., while jigs, standard gauges, and reamers were either among the things not yet dreamed of or among those only hinted at as being possible in the far off machine shops of the millennium.

There was there, to be sure, the wabbling grindstone in the corner, above which hung the white lead keg, emptied of its paint, but filled with water which dripped on the revolving stone, graduated as to the quantity escaping by a loosely fitted pine plug in the bottom. In the center of the shop stood the cannon stove, about which was heaped up fortifications of ashes, coal dust, and shop litter, and around which the cub machinist, petticoat lamp in hand, skirmished at night, stumbling, and barking his shins against the broken horse power machines and corn shellers that lay in ambush for him in the darkness.

Those of you who have chosen mechanical engineering as a profession, and who are to devise and direct the vast engineering plants of the future, will never have among your experience anything akin to what all the older members of the profession have had, of the upright drill of the "chalk age." You will never enjoy the luxury of hanging on the outer end of a scantling, the other end of which was under a beam, or the vise bench, and where between you and the beam a journeyman machinist, sitting on the floor with an iron brace and a flat drill, calmly and leisurely bored holes in a fire front or mended a broken casting. When I said calmly, I meant calmly, so long as the cub held the lever steadily, and the flat drill found no blow hole in the casting into which to drop in and stick fast; for when this happened, the plate would slip out from under the scantling, the wimble, the lever, and the cub usually came down together in a pile on top of the prostrate journeyman, who, scrambling from out the wreck, and alternately nursing a jammed finger and rubbing a bruised leg, added brilliancy to the tableau with the blue light of his profanity.

Neither will any of you ever enjoy the pleasure of being sent down with the workmen, some bitter cold winter morning, into the wheel house, to help chop out the old pitch-back water wheel which the night before had locked its icy arms with the forebay. Neither, after this has been accomplished, will you have a distinct remembrance how, for days afterward, the old wheel would revolve with diminishing speed, until shafts, and wheels, and pulleys, all through the shop, would almost come to a standstill, until the ice-loaded side of the wheel had passed the top of its revolution, and then with gathering motion for a few moments everything would fairly buzz with unwonted speed as the loaded side goes down.

I am sure that no graduate of Sibley College will ever have any experience in cutting bolts and tapping nuts with the appliances of this gone-by age. As I before said, there were no bolt cutting and nut tapping machines in the old time shops of which I speak, and I never look upon one of these elegant and polished thread cutting machines, in which the severest labor of the attendant consists in lifting the bolt up on the machine, and gently turning a lever to clamp it in its jaws, and then push it forward until it comes in contact with the well shaped dies, which, under a stream of self-pumped oil, cut on it a clean, smooth, and uniform sized thread, and which when finished is dropped into the sawdust bath below, but that I am reminded of the well named "jam plate" of my youth, and the flat sided taper taps that kept it company.

The rule of the smith was to swage down the end of the bolt until it would enter the nut, and the barbarous screw jamming tools, aided by the strained muscles and the sweating brows of the apprentice boys, bruised and raised up a thread outside the bolt, and inside the nut, so they would fit together. So uneven were their sizes, that each bolt and nut were fitted to each other, and when taking down a machine, woe betide the fellow who got them mixed!

I find that my time will not permit a description of all the tools of the old machine shop, few and crude as they were.

The old bull lathe, with the wooden shears (iron strapped) and the slide rest, and hand turning tools that belonged to it, have either been changed beyond recognition or buried under the scrap heap of the past. Neither can I describe even a few of the innumerable contrivances we were compelled to make in order that our scant tools could be made to do work which the new and improved tools of to-day would make nothing of doing. But all this had its value. When every day brought a new necessity, each day as well brought a new device for its accomplishment, until the machinist who learned his trade in those days, and in shops that had but few tools, had resources of experience and of expedients that gave him courage to attempt almost anything. It is a great pity that there has not been preserved, by means of cuts and drawings, some of these exceedingly ingenious makeshifts in the way of impromptu boring machines, facing off tools, drilling apparatus, and screw cutting attachments on engine lathes, etc. Many of them were curiosities in which odd wheels picked out of the scrap heap, joined with jiggers of all kinds and shapes, tied with clamps and long bolts made to do service as short ones, by having strung on them as washers a lot of worn-out nuts, the whole turned with a crank by hand, or by a rope, which, turning several corners, reaches somewhere a revolving pulley for the required power.

New and improved tools have done away for the necessity of such contrivances, and they have also done away, I fear, with the skill and ingenuity then required in the workman. There were giants in those days, in the way of workmen, who, with only a hammer, a chisel, and a file, could fit up in elegant style the strap joints and connecting rods which to-day come finished and polished from the machine tools without the aid of either. These were the days when the ways of lathes were chipped and filed, as were the guides for steam engines, and, indeed, all plain or dressed parts of machines.

I have not thus rehearsed the story of the "chalk age" simply to tell you what pluck, energy, and untiring industry then accomplished, but to give you an idea of the superior advantages you who are now before me, and who are seeking to become skilled in the mechanic arts, possess over those who have traveled over this road before you.

If, with the same high aims, the same undaunted courage, you start on this journey, aided as you are by all these fortunate surroundings, there will be no reason why the coming engineers may not at the last lay down their work with the same feeling of satisfaction as do the engineers of the present, as they look back on what has been accomplished in the half century just passed. And need I say that if the world's progress is to be aided by a corresponding epoch of great inventions, if it is to have its civilization, its commerce, its industrial pursuits, as well as its education and the general welfare of all, advanced with the same steady, onward march in the years that are to come as it has had in the years that have gone, it will be to the engineers which the technical institutes, the manual training schools, are to furnish, we must look for its accomplishment.

If you are inclined to think lightly of the task that is before you, if you are inclined to think disparagingly of the artisans and engineers of the past, and of what they have done, just, for a moment, think of what has been accomplished by them in the fifty years or so just gone.

Of course, you cannot remember the time when there were no railroads, no locomotives, no steamships, no telegraph wires on land or cables under the sea, or scarce of the time when the telephone had no existence, except in the imagination of Shakespeare when he spoke "of airy sounds, that syllable men's names."

You can scarce conceive of the time when there were not, as there now is, immense manufacturing establishments all over this land, in which everything, from the most delicate screw within your watch to the most ponderous engine, is turned out by machinery. For a description of the time in which all these things were unknown, you have not to listen to the "tales of a grandfather." Your fathers' remembrance will serve as well to enlighten you.

The world will never know, for it will never stop to consider, how much it owes to the inventor, the artisan, and the engineer of the past. While some of them lie in honored sepulchers and their memory is revered, vast numbers of them lie buried in unknown graves. Many sleep their last sleep in the village graveyard on the hill which overlooks the scene of their life's struggles. Some yet live, leading quiet, plodding lives, who in one way or another, by their genius, their industry, and perseverance, have done much to bring about the wonderful changes of which I speak. Here and there, as managers of vast iron and steel works, mines, and manufactories, which their genius created, may be seen moving about quiet, thoughtful men who, were they not pointed out to you, you would never dream were the originators of the vast industries they control.

In many instances most marvelous changes have taken place within your remembrance. There are places now busy with the hum of industry, whose towering chimneys blacken the air with their belching clouds of smoke, where the clamor of clashing wheels and shrieking whistles fill the air with strange sounds, and where the measured beat of immense steam hammers make all about to tremble; places where before a hundred fiery furnaces relays of swarthy workmen move to and fro, charging into their hot mouths or drawing from their fiery throats huge ingots of iron or steel, conveying them to gaping shears whose iron jaws bite them asunder, or to remorseless rolls which mash and mould them through unyielding grooves, and from out which the hissing, tortured metal writhes and twists like some great reptile in agony. If you do but follow the heated metal as it is drawn back and forward, pushed here and there, turned over and about as it would seem by unseen hands, helpless and as yielding as the clay in the hands of the potter, you will soon find it resting on its hot bed, a finished rail that shall bear upon its upturned head the traffic of the nation. And all this shall be upon what was, within your memory, a green meadow, beside which there flowed a placid river, and where the most energetic action within one's vision was the slowly moving yoke of oxen which on the hill side beyond leisurely dragged a plow; or the boy, sitting on the projecting trunk of a dead tree, watching with patience the too restful floating cork which even the passing breeze was too gentle to disturb with a rippling wave.

I can point you places where, but a few years ago, naught was to be seen but a worn-out cotton plantation, with here and there a tumble-down log cabin without doors or windows, ornamented at one end by a jagged stick chimney, and at the other with a coon skin stretched out to dry; and where the oldest and almost only inhabitant might have been seen sitting on the top rail of a worm-eaten fence, smoking leisurely a cob pipe, watching the while with half closed eye the lazy, floating buzzard that circles in the sky above him.

Go there to-day, and note the changes that have come over the sceene. Over lines of steel which reach from the storm-tossed waves of Erie to where the dull swash of the waters of the Gulf die away amid the lagoons of the South, from the sands washed by the Atlantic to the rocks of the Rockies, cars freighted with the product of many climes pass to and fro. From beneath the soil once plowed by the slave there now comes to the sunlight thousands of tons of coal to feed fires that go not out by day or by night, that give breath to panting engines, which in turn set aglow vast furnaces that light up the midnight hours so recently devoted to silence and to solitude. Along the vanishing furrows the plowman had left, lines of street cars are to be seen; on all sides, mills and manufactories give a hum of industry all unknown before. Churches, school houses, and costly dwellings have sprung up like magic amid the stubble fields of the past, and over the scene where ignorance and indolence so lately held undisputed sway, manufactures have bred commerce, and busy, whirling wheels have quickened the life blood of trade, until through every artery and vein it pulsates and flows with a force and vigor never before known beneath a southern sun. What has brought about this change? Who was it that waved above this hopeless spot the magic wand that woke it into life, and thrilled it into impulsive energy? Need I tell you it was the engineers, and largely so the mechanical engineers? Who are the mechanical engineers of our country? They are men seldom seen on any platform, men who are seldom heard in any public assembly, and whose names adorn no printed page. They are men whose lives have been spent amid the rumble of whirling wheels, the roar of flaming furnaces, the hum of spindles, and the click of flying shuttles. Among them are many whose forms have grown bent by labor at the bench or the lathe, whose eyes have grown dim by the feeble light of the workman's lamp, whose gray hairs and worn looks speak of hours of toil and nights of restless tossing, as they studied and dreamed on some then unsolved problem which, worked out later, has benefited all the world. They it is who have invented, worked out, and brought to their present state of perfection the steam engines as shown in the locomotive, the steamship, and the mill. They have devised and built the tools and machines that have made comforts possible in the poorest homes, luxuries in the richest. Their labors and their lives have advanced civilization, education, and all good things that have lifted the world up higher, made it more comfortable, more enjoyable, and better suited for the happiness of all in it; and I feel that I would not have done my duty at this time, to them and their memory, did I not say all honor to the mechanical engineers of the "chalk age."

THE TAY VIADUCT.

AT a recent meeting of the Institution of Civil Engineers, the president, Mr. Bruce, being in the chair, the first paper read was on "The Tay Viaduct, Dundee," by Mr. Peter Crawford Barlow, B.A., M. Inst. C.E.

The author stated that this viaduct, which carries a double line of railway over the Firth of Tay, at Dundee, was built to replace the former bridge, part of which was destroyed during the memorable storm of December 28, 1879. The viaduct was 10,527 feet in length, and of this a length of 7,397 feet was straight, and parallel to the straight part of the old bridge, the center lines of the two works being 60 feet apart. At the southern end the lines of railway branched westward toward St. Fort and eastward toward Newport, the junction being made upon brick arching of sufficient width for two double lines of railway. The northern, or Dundee, end of the viaduct formed a curve of 21 chains radius, and joined the existing railway, which was here parallel to the river. The gradient of the line was 1 in 762, falling from the southern shore to the navigable channel, where four spans, each with a clear headway of 77 feet above high water spring tides, were provided, and from this point a down gradient of 1 in 113·75 was maintained to the northern end. Out of a total of 85 piers, the foundations of 73 were formed of a pair of cylinders placed from 32 feet to 26 feet apart from center to center. In the case of the largest spans, the cylinders, which were of wrought iron, were 16½ feet in diameter at their upper ends, and were enlarged by means of conical sides to a diameter of 23 feet at their bases.

The second paper read was on "The Construction of the Tay Viaduct, Dundee," by Mr. Wm. Inglis, Assoc. M. Inst. C.E.

In founding the seventy-three pairs of cylinders from the platforms, the following quantities of materials were handled, namely: 2,300 tons of wrought iron cylinders; 680 tons temporary caissons; 26,000 cubic yards of excavations; 6,500 cubic yards of brickwork; 27,000 cubic yards of concrete; 22,000 tons of cast iron blocks to weight the cylinders. The superstructure of the piers consisted of two hollow octagonal pillars connected by a semicircular arch. Each pillar was temporarily erected at the works in Glasgow, partially riveted there, and the various parts marked for re-erection. The lattice girder work of the old bridge formed part of the roadway of the new viaduct. The girders were removed from their old position by floating them upon two large iron pontoons, 80 feet by 27 feet 6 inches by 8 feet deep, stiffened internally by lattice girders and water tight bulkheads. These were bound together by girders, upon which lattice columns were erected, fitted with telescopic portions that could be adjusted to at any required height. The pontoons were floated at low water underneath, and as the tide rose the telescopic girders were pushed up and securely pinned to the main column. At full tide the girders were free from the old bed plates and clearly afloat, and by manipulating mooring ropes, the pontoon was drifted to the site of the new bridge, a distance of 60 feet. On reaching its intended position the hydraulic rams which had raised the girder from the old piers were opened, and the span was allowed to drop into its place

on the new structure. The curve of the bridge at the north side of the river prevented this method from being adopted there, and the girders were transferred from the old to the new piers by means of traveling steam cranes. Most of the machinery used in the erection of the bridge was specially designed by Mr. William Arrol, the principal member of the firm of contractors, and the success which attended the work was the best testimony to its efficiency.

THE INTERNATIONAL GLASGOW EXHIBITION.

AN international exhibition was opened at Glasgow, on the 8th of May, under circumstances, says the *Engineer*, of the most favorable and auspicious character. Never, perhaps, did the metropolis of Scottish industry present a gayer appearance than it did when the Prince and Princess of Wales stepped out of the Central Station and took their seats in the carriage waiting for them in Gordon Street. The magnificent buildings for which the business part of Glasgow is justly celebrated were almost hidden in baize and bunting, while every window was crowded with holiday-keeping spectators. The street pavements were thronged with sightseers, who were only kept from spreading over the carriage way by the stout rows of railings which lined both sides of the route to and from the exhibition grounds. Venetian masts and floating streamers stretched in brilliant perspective for mile after mile; and as the royal procession passed with its long line of carriages and columns of mounted soldiery, the scene produced was one which the younger generation of Glaswegians will doubtless recount with enthusiasm in years to come.

The design of the exhibition building and its numerous adjuncts is certainly novel. The architecture of the Moors is certainly not suited in a general way to the atmosphere of a Scotch city; but, nevertheless, the exhibition buildings do not seem out of place when the sun shines upon them at Kelvingrove, and it is to be hoped, for the success of this deserving enterprise, that there will be very much sunshine in the West of Scotland during the summer of 1888. The coloring adopted consists of bands of yellow and red ocher, is in strict harmony with the architectural style, and the occasional glimpses of green to be seen on doors, windows, etc., seem somehow or other to heighten the effect without suggesting any sense of discord or tawdriness.

The general state of preparedness in every department on the opening day was much in advance of that which has been noticed in the cases of most of the preceding exhibitions of recent years. The machinery department is practically in complete working order. The steam machinery and dynamos employed in the electric lighting of the building and grounds is a center of much interest. Ten horizontal steam engines of not far short of 1,500 horse power are here situated, together with the dynamos for the Brush, Thomson-Houston, and King, Brown & Company's systems. The electric lighting has been duly tested and all found to be satisfactory. Leaving this interesting corner, we presently find ourselves surrounded with steam machinery for purposes associated with ocean and river navigation.

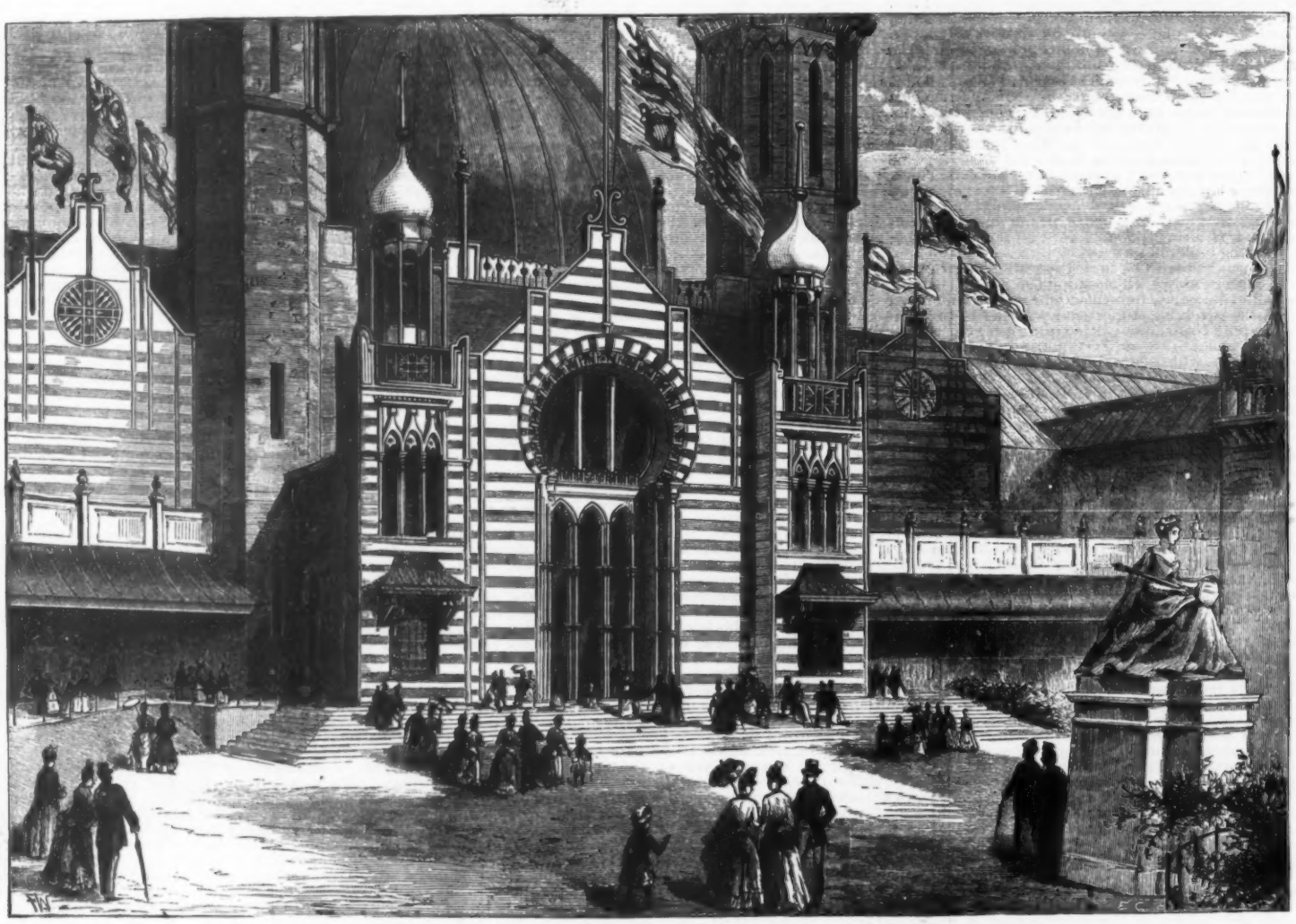
Messrs. Ross & Duncan are especially to be congratulated upon the wisdom displayed in preparing their most instructive exhibit, which is all the more interesting inasmuch as it is the only complete full size marine engine in the building. Messrs. Hawthorne show a model of the port engine for the twin screw Italian armorclad ship Sardinia of 22,800 indicated horse power. The Fairfield Co. show models of the triple expansion engines fitted in the Norddeutschen Lloyd's steamers Aller, Trane, and Saale, each of 7,500 indicated horse power. Messrs. Denny's model of the quadruple expansion engines fitted in the Compania Transatlantica steamer Buenos Ayres is a fine piece of work, the design being that of Mr. Walter Brock.

Messrs. Wigham Richardson & Co.'s model represents their system of triple expansion as applied to the SS. Alfonso XII. of 5,000 indicated horse power, while the Palmer Company's model is of a triple expansion engine as made by them to develop 1,100 indicated horse power. Naval architecture is almost entirely illustrated by models of more or less extent of detail and perfection of finish. The principal naval exhibitors are the Fairfield Shipbuilding Company, London & Glasgow Company, A. Stephens & Sons, W. Denny & Bros., Russell & Co., Simons & Co., R. Napier & Sons, R. Duncan & Co., J. & G. Thomson, A. Macmillan & Son, Lobnitz & Co., D. & W. Henderson, Fleming & Ferguson, and Barclay, Curle & Co., all of the Clyde, also Messrs. Wigham Richardson & Co. and Palmer Company of the Tyne. Probably the greatest interest in this section will be concentrated upon the cases containing Messrs. J. & G. Thomson's exhibits, including, as they do, most elaborately finished models of the Spanish war ships Reina Regente and El Destructor, H. M. S. Scout, the Atlantic steamers Servia and America, and, to crown all, a model of the Inman and International liner City of New York, now preparing for sea, which vessel is expected to break all past records in crossing the Atlantic.

The exhibits of the Fairfield Company eclipse all others in the department in regard to number and space occupied, and are by no means secondary in other respects. Among them will be found models of the Czar's circular yacht Livadia, of which so much was said at the time and so little is thought now; also of the swift paddle steamers Queen Victoria and Prince of Wales, Empress, Rouen, and Paris; besides a magnificent model of the North German Lloyd's' steamer Lahn; another of Sir William Pearce's yacht Lady Torfrida, and of the Saigon floating dock. Messrs. Denny's principal exhibit is a main deck dining saloon, a conspicuous object in the main avenue, which would be more ornamental in its effect if the exterior were only a tithe as beautiful as the interior. The purpose of this contribution appears to be that of showing that in a town like Dumbarton native artistic talent is to be found sufficient in quality and quantity to render the firm independent of all outside aid in the construction of as elaborate and chaste a work of art as is to be found of its kind throughout the entire exhibition. The hand painted panels, carved friezes, and artistic roof are worthy of the highest admiration, and when the whole is illuminated with the incandescent electric light the effect is so charming that one shudders at their contingent association with the horrors of *mal de mer*.

The Messrs. J. & G. Thomson have also a deck house saloon adjacent to that of the Messrs. Denny, but of a smaller and less elaborate character, although sufficiently chaste to be well worthy a place in the SS. City of Paris. Each of the Clyde shipbuilders seems to have his special line of business. Some show little else than sailing ships, others seem to lay themselves out for the construction of dredging craft, while a still more numerous class compete in the production of the magnificent ocean liners for which the Clyde has acquired so high a reputation. Some of the larger firms, such as Fairfield, Napier's, and Thomson's, show a great many war ship models—the last named particularly being now to the front as designers as well as builders of armorclads and cruisers.

Passing from the naval section, we turn to those departments which furnish either raw or manufactured materials for shipbuilding and marine engineering. Being in the center of a district which produces a very large fraction of the Siemens-Martin steel used in shipbuilding and in engineering structures, it is not surprising to find an excellent display of this manufacture. In the machinery department, very near these boiler exhibits, are to be seen Rowan's electro-magnetic motors in full work, both as drilling and riveting machines. It is of no use to employ excellent materials for ships and boilers unless they are efficiently fastened, and Mr. Rowan here shows by work he is doing on the portion of the side of a steel ship, erected in the building, that the drilling of true and fair holes by electricity is a mechanical and economical possibility. Sufficient has, perhaps, been said to show that the Glasgow exhibition has been considered of sufficient importance to induce the engineers, shipbuilders, and manufacturers of the country to contribute largely of their wares, and that the building is well stocked with those exhibits which are best calculated to awaken the interest of all classes of the community in this member of an already numerous series of British industrial exhibitions. To the *Illustrated London News* we are indebted for our engraving.



THE INTERNATIONAL EXHIBITION BUILDING, GLASGOW.

THE NEW CABLE STEAMSHIP AMBER.

THE new telegraph cable steamer Amber, the fifth vessel of its kind for the Eastern Telegraph Company (limited), has been built and engined by Messrs. Robert Napier & Sons, of Govan, Glasgow. She left Gravesend recently for Cadiz, and is now employed on some cable work there.

The Amber is the smallest vessel of the company's fleet, but owing to the engines having been placed in the after part of the ship, thus leaving available the best part of the ship for cable tanks, saloon accommodation, berths for officers and crew, the ship is rendered thoroughly efficient for any description of cable repairs required.

The dimensions of the steamer are as follows: Length 210 ft., breadth 31 ft., depth 24 ft., her builder's tonnage being 978 tons, net register tonnage 557 tons.

Being built for an awning deck (class 101 A 1 at Lloyd's special) she has an uninterrupted deck fore and aft, with head and stern sheaves, giving every facility for the work in which she is to be engaged.

The vessel is wholly built of steel, and all the most modern appliances have been adopted, including steam

steering gear; the engines are triple expansion, the cylinders having a diameter of 19, 30, 46, by 36 stroke, pressure 170 lb., driving the ship at a speed of 13 knots on an easy consumption of coal.

The cable gear is the design of Messrs. Latimer Clark, Muirhead & Co. (limited) on the tandem principle, driven by two separate engines, which can be united together and exert either their full power, if found necessary, on either of the drums, or can be separately used on one or the other drum independently.

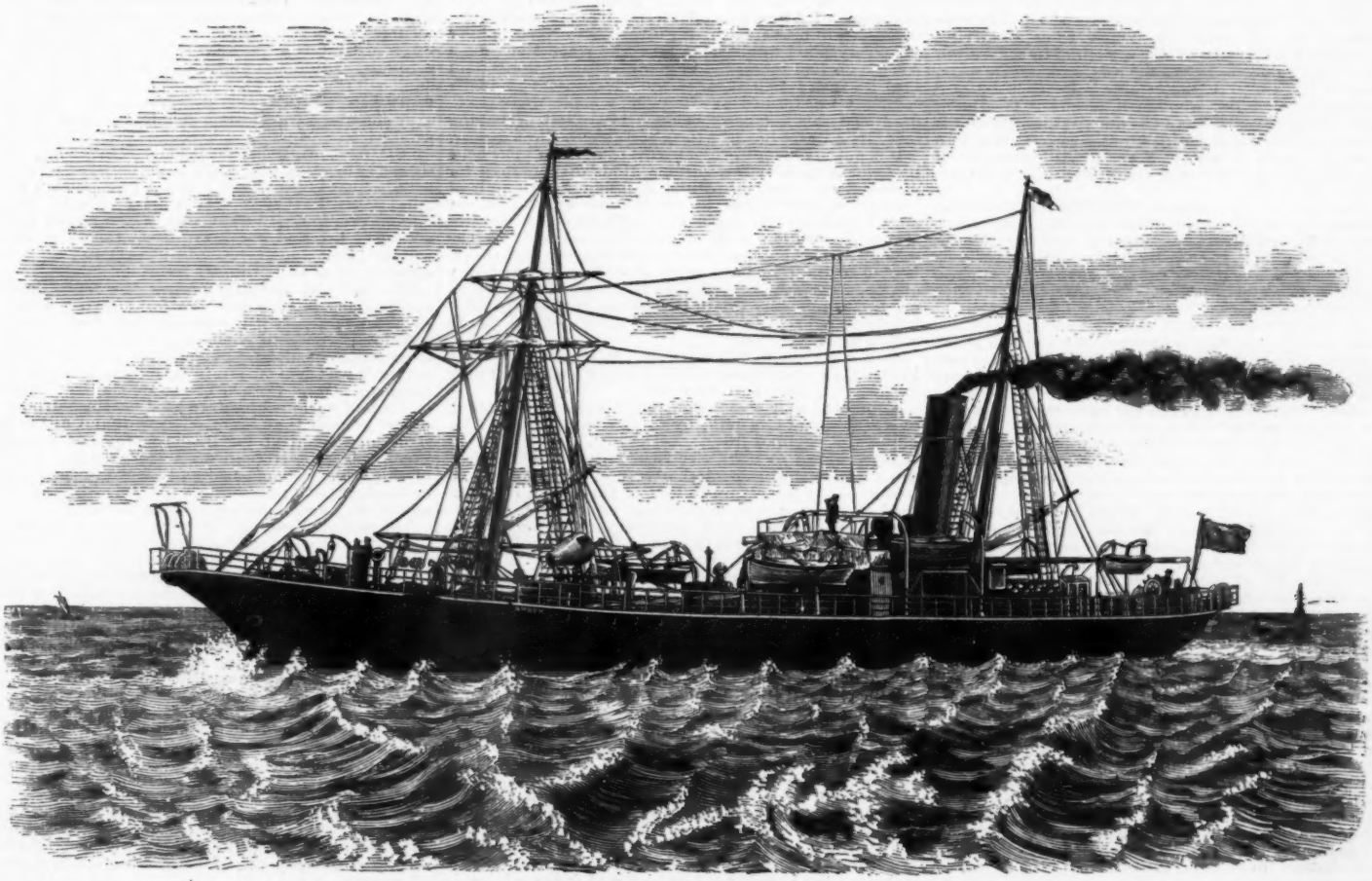
The electric lighting and search lamp is by Messrs. Johnson & Phillips, of Charlton, Kent.

The saloon is amidships and is very tastefully finished, being enameled white and gold.

The illustration will give a general idea of this ship, which is beautifully lined. It is the third ship of its kind which has been built. One was the Magneta, the other was the Electra, the cable gearing of both of which vessels was manufactured by Messrs. Johnson & Phillips.

The dimensions of the Amber are rather less than those of the two vessels just named, each of which was 230 ft. in length and 32 ft. in beam, their (builder's) tonnage being 1,096 tons. The Amber's depth, however, is the same as her predecessors.

It will be remembered that the Magneta was lost, with all hands, about three years ago; and the new steamship Amber has been designed to take her place. The Amber is fitted with all the latest and most approved appliances for cable laying and cable repairing, and is, it may be said, the outcome of the varied and wide experience which the owners of these vessels have gained in their important operations.—*The Electrician.*



THE NEW CABLE STEAMSHIP AMBER.

ASBESTOS.*

By FRANK ALFRED ROGERS.

ASBESTOS is a substance so far outside the range of practical pharmacy that an apology would almost be necessary for making it the subject of a paper, were it not for the fact that the practical uses of asbestos are to many little imagined, and in bringing it for discussion before a meeting of practical pharmacists, I do so with the hope that many more applications and uses than are mentioned in this paper may be found for it. I would remind you that in many instances it has been proved that it is not only its suitability for resisting fire on a large scale to which it owes some of its, may I say, grandest successes, but also in its application to what may, perhaps, seem almost trivial matters, were it not for the fact that we are not judges of what is or is not trivial.

As I take it, the general impression regarding asbestos from a chemist and druggist's point of view is something of this sort—that it is a substance we are never really sure we keep in stock until looked for; a substance generally kept in a locker along with other things required very seldom; occasionally useful for straining purposes, on account of its being almost entirely unaffected by acids, oils, etc., and there the matter ends. I purpose to-night, as far as I am able by the aid of the specimens on the table and the facts I have accumulated, to present this substance to you under a slightly different coloring, and to show you what has already been done with this remarkable *natural* product, and to hope that many more useful capabilities may be found for it (as I am sure they can be) in our laboratories.

Upon thoroughly settling down to work upon the subject, I was astonished at the mass of evidence already borne to its usefulness, especially so as about forty or fifty years ago practically little was known about asbestos, or where it could be found; and may I not say that even now comparatively limited is our conception of what it may still prove capable.

I purpose treating the subject in two sections:

1. Descriptive of where and how it is obtained, and general appearance.

2. Descriptive of its numerous applications.

Asbestos takes its name from the Greek word "asbestos," meaning "inconsumable," and is a variety of the amphibole or hornblende family of minerals, and akin to tremolite and common hornblende. According to mineralogists it is a fibrous silicate of calcium and magnesium. The composition of the whole family is chiefly silica, magnesium, aluminum, and ferrous oxide, but varies considerably, those containing most iron being most easily fusible. Its most familiar allies with which we have practically much to do are *soapstone* (magnesium-aluminum silicate), and asbestos is supposed by some chemists to be soapstone in a different form, *pumice stone* (a porous silicate of aluminum and of alkali metals), and *hornblende* (magnesium and calcium silicate with a little iron). It is found in the older crystalline, but more generally in the serpentine, rocks, and is distributed almost over the entire earth, having been found in Italy, Spain, France, North and South America, Sweden, Ural Mountains, Silesia, New South Wales, Corsica, Japan, Switzerland, South Africa, and in Scotland, Anglesea, and Cornwall. But the two countries from which it is almost exclusively obtained at present are Italy and Canada, and as the quality of that derived from the former is far superior to that from the latter country, I purpose dealing with that first.

But before proceeding to do so, let us get a general idea of what asbestos is. We have seen what it is chemically, and I wish to say here that I make no mention of *how* asbestos is formed in the earth, for the reason that, as far as I am aware, nothing is really known on this head. Several theories have been put forward, but as they are all mere conjecture, I have thought it best to leave them unstated.

On referring to the "Encyclopædia Britannica," we find the following:

"Asbestos consists of fine crystalline elastic fibers with a silky luster, varying in color from white to gray and green, and derives its name from being specially indestructible by fire. A single fiber of it fuses to a white enamel, but in the mass it is capable of resisting ordinary flame, and has on that account been regarded from ancient times as a most interesting substance. Woven into cloth it forms a fireproof texture, which to be purified requires only to be thrown into the fire; gloves, napery, towels, handkerchiefs, and even dresses have been woven of it, and it is said that the ancients used to wrap the bodies of their dead in asbestos cloth to keep their ashes separate from those of the surrounding funeral pile."

The three samples (fibrous, floss, and powder) you have now before you are varieties of *Italian* asbestos. *The fibrous* is lengthy and tough, and feels somewhat like soapstone, and varies in color from white to gray and brown. *The floss* is like silk, but dry, and of a beautifully white color. *The powder* varies in smoothness and color, like the fibrous.

Fibrous Italian Asbestos.—This variety is principally found in the Valtellina and valley of Aosta. It was first discovered in the valley of the Valtellina, about 5,500 feet above sea level, where, surrounded by loose bowlders and stunted pines, stands a serpentine rock, near the top of which it was found, in a nearly horizontal course through it, changing, however, to a vertical direction and going down into the rock almost like a corkscrew. Descending further into this valley we find a large excavation in the side of the rock, traversed in every direction by thin seams of asbestos, which seem to start as from a center and spread out in every direction, and these again are crossed by thin seams both horizontally and diagonally.

These seams generally converge to a center, where the various thin seams unite themselves, and there a quantity of asbestos may be found, then all appearance of it ceases, only to reappear in the same form when further worked into. On account of the irregular way in which it is mixed up with the rock, the only method of working it is by blasting with dynamite. Further down this valley other seams of fine fiber were found, which on being worked followed a semicircular direction, entering a good way into the mountain side, and finally changing course came again to the outside, leaving a large isolated rock in the center. The finest piece of asbestos, I believe, yet found was discovered in this working. Asbestos is found all over the rocks on the north side of the valley, and is worked in a similar way to the above.

In the table land of Acqua Nera, 6,500 feet above sea level, the whole western rock is rich in asbestos, but here the seams follow a nearly vertical direction. Going further north, the chief source is in a deep narrow valley, the rocks on either side presenting the appearance of having been ground smooth by a glacier; and here asbestos is found almost everywhere. The seams here followed a circular direction. In the center the rock was quite friable and soft, and the asbestos of poor quality, while at the circumference the rock was very hard and the asbestos of fine quality. In this district it is found up to 10,000 feet above sea level, and it is sometimes worked at this height, but in some years the seams remain buried in snow. Very different surroundings from those at the valley of Aosta mines, where the workings are either in pine or chestnut woods or among meadows, seldom exceeding 6,000 feet. There are numerous workings all along these mountains.

The next principal Italian mines, as previously stated, are those of the valley of Aosta, a place greatly resorted to in summer for its mineral waters. The workings are exposed to the south or southwest, and the formation is similar to that in the Valtellina. When asbestos is first found in any new place, the general appearance of the rock is that the cracks are filled up with a white powdery substance; this, on being removed, presents a leathery-looking substance, under which the true asbestos may be, but is not always, found. We saw just now that the face of the workings was toward the south or southwest; the importance of this will be gathered from the following practical conclusions of the Italian employes: "If asbestos be found on the face of a rock, exposed to either the south or southwest, the product is generally fairly abundant and of good quality. If exposed to the east, there is a fine quality, but very small quantity, while if exposed to the north the quantity is plentiful, but dry and hard, and on entering into the rock all traces of it are lost."

It will thus be seen that very great care and discrimination have to be exercised before a new vein is worked,

* Read at a meeting of the Chemists' Assistants' Association.—*Pharm. Jour.*

as it may, while appearing valuable, prove worthless. Asbestos of good quality is only found in the serpentine formation. The following analysis of *Italian* asbestos is by the late Professor Barff:

Lime and magnesia	37·84
Silica	41·69
Oxide of iron	3·01
Potash	0·85
Soda	1·41
Alumina	2·57
Moisture evap. at 100° C.	3·04
Loss on heating to white heat, water of hydration, and organic matter	9·56
Loss	0·03
	100·00

Years ago, when asbestos was little more than a mineral curiosity in geological collections, there used generally to be specimens obtained from the eastern part of the Alps, partly from Switzerland, but chiefly from certain localities in the Tyrol. The impression was that that found in connection with hornblende or amphibole was the best. This contained a larger proportion of alumina, whereas from the analysis the most valuable kinds contained a larger proportion of lime and magnesia and were found in the serpentine formation. The serpentines in various parts of Europe could hardly be examined without finding them intersected with fissures, which, generally speaking, ran from ¼ of an inch to 2 or 3 inches in breadth, and contained asbestos of more or less suitable quality, but the fiber was so short as compared with those before you as to exclude them altogether from practical use.

Floss Fiber.—Varieties in which the fibers are very delicately and regularly arranged are called "flexible asbestos" or "amianth" (a Greek term signifying "unpolluted"). Traces of this are found in the Valtellina and the valley of Aosta, but it is found and worked in part of the chain of mountains between Susa and Turin, about 8,000 feet above sea level. It is usually found in thicker seams than the fibrous quality, and is generally horizontal and dips rapidly as you enter into the rock. There is always a very large quantity of short powdery matter found along with it. There are many varieties, as:

Mountain Cork and Mountain Leather, in which the fibers are less flexible and regular than in either of the above, and instead of being parallel, are interwoven, the color being brown or dirty white. *Mountain cork* is so named from being not unlike common cork, and so light as to swim in water. *Mountain leather* is in thin, flexible sheets.

Mountain Wood is a soft, tough, opaque, brownish colored variety, and much heavier than the two previous kinds. These three varieties of floss fiber are not, however, at present used commercially, and are merely objects of curiosity.

Asbestos Powder is found in the same range of mountains as the floss, but at a much lower elevation, about 5,000 feet. It was noticed after a large landslip, and when first seen was of a pasty consistence, but on exposure to the air crumbled into powder, the important use of which will be referred to later.

Having thus considered the Italian asbestos, we now pass on to glance at the Canadian variety. I would draw your attention to the difference between the two, the Italian being superior in every respect, especially in its capabilities of being woven into cloth. Many instances have occurred in which cotton has been mixed with asbestos by American manufacturers, but the samples of finished material before you are all made of pure fiber.

Canadian Asbestos.—You will notice at once the chief characteristics of this variety. It is short and brittle and much inferior to Italian, being only about 1 to 1½ inches long, and so weak that for a long time it was considered impossible to weave it. This difficulty, however, was overcome, and there are samples on the table of the cloth. It is mined only in the province of Quebec. In the township of Broughton there is a small deposit of asbestos of very long and fine fibers, but the seams are few and uncertain, while to the southwest they are found so much mixed with foreign substances, such as chrome iron, that they cannot be worked. The whole district in which asbestos is mined has a radius of about ten miles. The mining is wholly conducted by opencast or quarrying. One peculiarity about Canadian asbestos is that although fire-resisting and proof against acids, etc., yet it is very easily damaged if exposed to rain or water in its crude state, becoming hard almost like wood.

The following is an analysis of *Canadian* asbestos:

Lime and magnesia	33·20
Silica	40·90
Oxide of iron	5·75
Potash	traces.
Soda	0·68
Alumina	6·60
Loss on heating to white heat, water of hydration, and organic matter	12·50
Chlorine	0·25
Loss	0·12
	100·00

Since writing this I have had placed in my hands a sample of asbestos from the *Cape*, with the analyst's report upon the same, from which I have extracted the following:

"The sample contains a considerable quantity of iron; ordinary commercial asbestos contains only 2 to 4 per cent. of oxide of iron, while this specimen has as much as 39 per cent. The fiber is fairly strong, and provided the material does not alter by exposure to air, it would be suitable for weaving into cloth. It will not, however, stand any degree of heat without disintegrating and becoming quite rotten. This effect is probably due to the fact that a portion of the iron is in the form of a ferrous salt; by exposure to air and heat this salt oxidizes and alters the composition of the asbestos to such an extent that it is easily converted into a powder. This powder would answer the purpose of a fire-proof paint."

We have now become acquainted with where and how asbestos is obtained, and come to the second section of this paper, viz.:

The Applications of Asbestos.—Its valuable fire-resisting properties have been known for upward of two thousand years, and advantage has been taken of its qualities for the performance of clever trials of fire-handling, etc. It has been used by the peasantry in the regions where it is found as an indestructible lamp-wick, its power of capillary attraction rendering it specially adaptable to this purpose. In the early time the art of weaving the cloth was its chief application, and was much valued. There is in the museum at Naples a piece of cloth of ancient Roman or Grecian manufacture, which is so similar to that now made that very few persons would be able to detect the difference. There is also in the Vatican a piece of asbestos cloth which is supposed to be one of the napkins which are said to have been used by popes and emperors. It is stated that Charlemagne had a table cloth made of this material, which he used to have thrown into the fire after dinner for the astonishment of his guests. As I stated in a previous part, the Greeks are said to have used asbestos cloth ages ago for wrapping up the bodies of their dead, to keep their ashes separate from those of others in the funeral pile, and as many of us are glad to see that the practice of cremation is gaining ground again, I submit that this use for asbestos may be again a practical and useful one. The asbestos from which these cloths were made is supposed to have been found at Paphos in the island of Cyprus, and recently asbestos has been found in this island.

From the year 1850 various attempts were made by Italians to utilize asbestos, especially as regards its manufacture into cloth, and chief among those who did this was the Chevalier Aldini, of Milan, who is said to have had a complete dress made of the cloth, and to have made very successful experiments with it by way of testing its protective power for firemen. Among those to whom we are indebted for the first mechanical applications was the Italian priest Guiseppe della Coronna, of Florence. After many experiments he succeeded in making asbestos into millboard and paper of a very good quality. About the same time some Americans had succeeded in manufacturing the Italian asbestos into packings for piston glands, and in 1872 a company was formed at Glasgow to make these packings. To this company belongs the merit of having first offered asbestos in a form suitable to the engineer.

It is not my intention, to-night, to take up your time by describing fully the various kinds of packings for piston glands, etc., into which it is made, although at present, on account of its remarkable durability, the most numerous and important applications of asbestos are in connection with engineering, specially in the case of marine engines under high pressure and superheated steam, that have to be at work night and day on long voyages. Samples of the chief kinds are on the table, and will explain themselves sufficiently. But briefly to refer to the other and more general use to which it has been put:

In the Form of Millboard.—It is largely used as a jointing material between steam pipes and as a lining for fireproof cases and deed boxes.

A common source of fire is from gas shades becoming overheated and igniting; by using shades made of asbestos this is impossible.

As a tubing to hold electrical wires, which is fireproof and waterproof and also non-conducting, and preserves the perfect insulation of the wires; it is also used to form a non-conducting envelope for steam pipes. Paper has been manufactured from it, and would prove invaluable in case of fire for public documents, etc., were it not that the paper is rather tender to use and that the writing disappears after a red heat. It is made into a wall paper, and at the present time is being used in this form in Belgium, under an order from the government, for papering stage scenery, with very good results.

In the Form of Cloth.—One of the most valuable uses to which asbestos has been put is as fireproof curtains for theaters. You will remember after the burning of the Ring Strasse theater in Vienna great attention was called to the necessity for providing some form of curtain for perfectly isolating the stage from the other parts of the house. And since the frightful disaster that occurred at Exeter some few months ago, several theaters in town and country (Terry's in London, Queen's and others in Manchester, and in Hull, Sheffield, and Birmingham) have been supplied with asbestos curtains. Both iron and other curtains have been tried, but found to be ineffective.

It has been largely used by beet root sugar refiners in Germany for filtering purposes, filter bags of asbestos being found very much better fitted for this purpose than those of canvas, as they are not affected by the acids generated in the manufacture of the sugar, and are easily cleaned.

It is also extensively used for the filtration of both acids and water.

A strong, coarse make of this cloth is often used for protecting the clothes of men employed in the manufacture of strong acids and for fireproof clothes for firemen, and might advantageously be used for making bags for the transportation of gunpowder.

In the Form of Floss Asbestos.—It is principally used in the manufacture of gas stoves in the shape of single fibers or balls, which not only present all the warm and comforting appearance of a coal fire, without its accompanying dirt and trouble, but are sustained when once fairly heated by a comparatively small supply of gas, the balls also being used to save the consumption of coal by being placed in among ordinary fires. In speaking of the mining of this variety of asbestos, we saw that there was always a large quantity of short powdery matter found with it; we will now see to what uses this is put.

One of its most important applications is for covering steam boilers and pipes to prevent the radiation of heat, and also to *economize the fuel*. To apply this it is made about the consistency of mortar, and is mixed with certain chemical ingredients which, although not injurious to the metal, cause the asbestos to adhere to the plates, and when dry it sets quite hard. With a boiler carrying say 80 lb. pressure the application of from 1½ to 2 inches of this composition so well retains the heat in the boiler that a thermometer with its bulb held close to the surface of the covering will not indicate more than 80° to 85° F. It has also been used in excessively hot climates as an external covering for houses, in which under ordinary circumstances the heat was almost unbearable, with the result that whereas the temperature outside was about 100° F., inside it did not exceed 70°.

On considering this variety of asbestos and its applications, we thus see that it is equally valuable either for excluding or retaining heat; and when we recollect that we live not so much for our own generation as for the future ones, and that all the learning of one age is merely the stepping stone for the further advancement of the next, we can think of nothing that will be of more importance than our coal supply (the failure of which I take from a trustworthy authority is not so far off as is imagined). We in our time have no cause for uneasiness on this head, but when we think of the enormous amount that is annually consumed, we cannot help but feel almost alarmed for the time when it will have to be dispensed with. Granted, you will say, that our successors will have so far eclipsed us as to have found a means by then of utilizing the enormous force at present lying dormant in the tides. Still I venture to submit that it is our duty to see that we make no abuse of our at present abundance, but that we endeavor, if possible, to utilize it more and more thoughtfully; and not only does it present itself to us in this light, but in that of *economy*, which is the one aim of both the natural and inventive world. This economizing can be performed by the means of asbestos in many other ways than the two mentioned, and I venture to say that, in the future of electricity, we have little idea of the important part asbestos will play.

There remains but one other variety of asbestos to consider, viz.:

In the Form of Powder.—In which its chief and most important application is in the form of a *paint*. You are probably aware of the numerous experiments which were performed some four or five years ago, to prove the perfect fire-resisting properties of wood covered with this paint, as compared with others not similarly protected. This was established without a doubt, and no better demonstration could possibly have occurred of its value than took place at the South Kensington exhibition in May, 1884, when the stall of an exhibitor caught fire and would have spread and endangered the entire building, but for the fact that the walls were painted with asbestos paint. The various experiments have clearly shown that this paint will preserve woodwork from being consumed by the action of fire for a considerable time, and although by continued subjection to a fierce heat the wood underneath may become charred, yet it cannot be a means of communicating the fire to surrounding objects. Samples of wood coated with this paint, which resists both the action of fire and water, are upon the table, and you will see that in all respects it presents as good an appearance as any ordinary paint.

The last and certainly one of the most important applications is as a *medium for filtering water*. To effect this purpose it is essential that there should be a sufficiently energetic chemical action for the removal or destruction of deleterious matter in solution and a perfectly mechanical straining for the removal of suspended matter. Porous blocks or slabs of carbon or silicates of various kinds are used for this purpose; but sooner or later they become clogged, and although instructions are given for the brushing and scraping of these, it is impossible to do it thoroughly. If instead of this a carefully cleaned and carded layer of asbestos be used, the above essentials are perfectly carried out, and it can be changed and cleansed easily.

You will thus see that the chief value of asbestos lies in its *fire-resisting, acid-resisting*, and *fibrous* qualities, and in all its different applications these qualities have been kept in view. When we consider the number of firms engaged in it, and that its manufacture has gradually grown during the last few years from almost a private speculation to become one of the staple industries of the country, it would be impossible to say now to what an extent it may be further carried, and what better augur could be wished for its future usefulness than this. I have endeavored to give you its most interesting and practical applications, and although I have been able to name but a few of the many ways in which it may be used, I leave the subject to your more scientific and practical experiences for that development which it is capable of, feeling it cannot be left in better hands.

In conclusion I have to thank the United Asbestos Company, of Queen Victoria Street, for their kindness in providing me with the chief part of the information on which this paper is based, and for the complete set of samples on the table, which give you an idea of the importance of the industry.

CEMENT FROM WASTE PRODUCT LIME.*

By J. S. RIGBY.

THE question of waste products in the manufacture of alkali has long been a source of trouble to the manufacturer, and any feasible method of disposing of the same must be hailed with satisfaction, especially where such method is at once a means of disposal and at the same time a source of profit.

In bringing this matter before the public, I have been encouraged by some of the largest alkali makers in the trade, who have unhesitatingly adopted my process for the manufacture of Portland cement from lime mud.

Portland cement, as most of you are aware, takes its name from its resemblance to Portland stone. The seat of the manufacture is on the Thames and Medway, where it is made from chalk and mud, both existing in almost unlimited quantities in the same neighborhood. A comparatively small quantity is produced in North Wales from the carboniferous limestone, and in the Midlands from the lias limestone, which contains from 10 to 20 per cent. of silica and alumina, with a small percentage of oxide of iron. It is ground by the aid of suitable machinery as finely as possible and mixed with shale (in the same fine state of division) containing silica and alumina in such proportions that will produce approximately a cement corresponding to the following analysis:

Lime	62
Alumina and iron	10
Silica	22

It is of the highest importance that the lime should exist in as near the quantity named as possible. A very slight divergence would alter the quality of the cement very materially; an excessive quantity of clay would give a cement of a brown color, having a low tensile

* Read before the Society of Chemical Industry at Liverpool University, by Mr. J. S. Rigby, on April 4, 1888.

strain. Lime in excess is also to be deprecated, for it necessitates the purging of the cement, as it is termed—that is, the cement is spread out on floors so as to admit of the hydration of the lime; in some of the works where the cement is produced from limestone, it is usual to keep it for two months, turning it from time to time, thus entailing considerable expense.

Makers of cement have suffered severe losses through their lack of knowledge in not being able to ascertain the quality or estimate the component parts of the cement-producing mixture. Some of the large works now employ chemists, and so carry on the business in a scientific manner.

It will be seen from what has been stated that it is essential in the production of cement to have a carbonate of lime in as fine a state of division as possible, either in the form of ground limestone or chalk.

Carbonate of lime, as a by-product, has been produced by alkali manufacture for the past thirty years, and in a state that will compare favorably with the finest ground limestone, or even chalk. This substance, commonly known as lime mud, has always been a source of trouble to the manufacturer. To use it as a substitute for limestone in the black ash mixing retards the process very considerably, owing to the amount of water the mud contains, the best appliances in the shape of filter beds and pumps failing to reduce moisture to much less than 30 per cent.

Some manufacturers have sent the lime mud away as refuse at a considerable expense, while others run it into the river.

When alkali was of far greater value than it is at the present day, there was not the same necessity to study economy so strictly; now we find what have been hitherto waste products have been utilized with considerable advantage. In the case of lime mud, having experimented with it (some two years ago) with a view to manufacturing Portland cement, I came to the conclusion that, by proper manipulation, and by washing the mud as free from alkali as possible, and eliminating the sulphur compounds, the alkali manufacturer had in his hands a substance as valuable for cement making as chalk, with the advantage over the latter substance of being free from flints, and in a state ready for mixing with the least possible trouble.

In the first instance I made a cement from the lime mud without the latter being purified, and found it produced a cement of a very uncertain nature; when made into briquettes and placed in water, they frequently crumbled away, or if they held together at all, a very slight strain caused them to break. The cement had also an unpleasant slippery feel with it when taken from the water; it also evolved sulphureted hydrogen when treated with an acid.

I expected that the sulphur compounds would have been decomposed by coming in contact with the $C O_3$ evolved in the decomposition of the $Ca C O_3$ during the process of making the clinker in the kilns, but in every instance I found sulphides present. Knowing that it was most important that Portland cement should be free from sulphides, I endeavored to eliminate them from the lime mud. I found by passing $C O_2$ through a mixture of lime mud and water, a chalk was produced that quite answered my expectations; the $C O_2$ can be obtained from the kiln during the decomposition of the slurry (a technical term for the mixture of clay and chalk). It has also suggested itself to me that the $C O_2$ from the above process could be used in Chance's process for the recovery of sulphur from alkali waste, instead of burning limestone especially for that purpose, or the new process of Simpson and Parnell for the same purpose, now being worked by the Lancashire Sulphur and Alkali Co. at their works, Widnes.

I will now give you a brief description of my process for the manufacture of cement from lime mud. It is very similar to the method adopted in ordinary cement works, with the exception that the chalk or lime mud requires purification before being calcined. Either before or during the process of mixing the lime mud and clay (say the latter), I take the lime mud direct from the filters, after being washed as free from alkali as possible, and mix with a good unctuous clay in such proportions that will produce a cement corresponding to analysis already mentioned. It is highly important that every attention be paid to procuring a reliable clay of regular quality, for upon this depends the success of the operation; an upland clay, containing as it generally does a considerable amount of sand, will not produce nearly so good a cement as that made from river mud, which is an alluvial deposit and free from the impurities contained in the upland clay.

After the lime mud and clay have been thoroughly mixed with a sufficient quantity of water to reduce it to a consistency that will admit of its flowing easily, I run it on to a drying bed to a depth of from a foot to fifteen inches (the drying bed consists of a series of flues covered with tiles at the end next to the fire and iron plates at the cool end, so as to utilize the heat as much as possible). Heat is generated in ordinary fireplaces and passes through the series of flues to the chimney; the drying operation occupies about four days. The heat causes the mixture to crack, and generally forms pieces of a convenient size for handling.

By using a kiln that was patented some years ago, the drying on the beds mentioned is obviated, and a great saving effected both in fuel and labor. The kiln is so constructed that the heat generated during the calcining process dries the slurry, and is at the same time convenient to the kiln for charging.

(Here shown.) Samples of slurry made with upland clay and river mud, the former is ordinary brick clay. The mud can be procured from the Mersey on the Cheshire side, extending from Bromborough to Rock Ferry; it is also found near Hale Head, on the Lancashire side of the river.

The slurry, as you now see, is a mechanical mixture of lime mud and clay; cement is supposed to be a silicate of alumina and calcium, but as yet we have no decided authority upon the matter. To effect the decomposition of the mixture it is placed in kilns, with alternate layers of coke, until the kilns are filled. The kilns now being used by the Widnes Alkali Co. at their Seacombe works are the ordinary dome kilns, and will contain when filled 30 tons slurry, and will produce about 20 tons of clinker. A very high temperature is attained during the process of decomposition, which occupies on an average about three days. The eyes or openings in the kiln, which have been loosely built up with bricks and plastered, are now opened, and the clinker allowed to cool. One or two bars are then removed from the bottom of the kiln, and the clinker with a very little assistance is discharged on to the floor, to be loaded into barrows and conveyed to the crusher. Any pieces that have not been decomposed are put aside to go into the next kiln.

It is an easy matter to judge what quality of cement the clinker will produce, by its appearance as it leaves the kiln.

A clinker produced from a slurry containing an excessive quantity of clay, upon coming into contact with the atmosphere, will gradually disintegrate, forming a fine powder or dust utterly valueless.

A clinker containing lime in excess is of very dark color and very difficult to grind; the resulting cement has a rough, gritty feeling, and must be allowed to remain in the house until the uncombined lime has become hydrated. Good clinker possesses a bronze-greenish appearance.

The crusher mentioned is an ordinary Blake's crusher; the clinker when passed through it is broken to one inch size and deposited into a recess, from which it is elevated to a large hopper placed over two pairs of stones. It is gradually passed through the latter, to be again elevated and deposited into a chute containing a worm that conducts the ground cement to a screen varying in fineness from 2,500 to 3,600 holes to the inch. Particles that have not been ground sufficiently to pass through the screen are, by a suitable appliance, caused to pass through a small pair of stones situated near the screen, where it is rendered sufficiently fine to pass into the store.

Cement made from lime mud, which, as you are aware, is a carbonate of lime in a most finely divided state, is equal in every point to that manufactured from any other source; it is capable of standing a high tensile strain, as will be seen from the following results obtained by an old firm of cement makers in this neighborhood, who adopted my process over six months ago.

Briquettes (similar to these) stood the following tensile strains:

Two briquettes, after being made seven days, six of which they were immersed in water, showed—

No. 1	1053 lb.	:	
" 2	1210 "	:	7 days on the 2¼ in.
	1326 "		14 "
	1475 "		39 "
	1612 "		61 " Not broken.

These tests, made by independent cement makers, are satisfactory evidence of its quality. As regards the sp. gr., it is equal to standard requirements, a bushel weighing 118 lb.

This sample of concrete was made by mixing six parts of limestone to one of cement; it was sawn through, to show adhesive power of the cement, some few weeks ago.

The Widnes Alkali Co., limited, have been manufacturing about fifty tons of cement, weekly, since the beginning of the present year (and to obtain that quantity they mix about seventy tons lime mud with twenty tons clay). This has been readily sold to local users, the Manchester Ship Canal, and for export.

After carefully going into the prices of material, etc., I find the cement can be produced at a much less cost than ordinary Portland cement; of course this is obvious, as it is made from what has hitherto been a waste product, having as well the advantage of cheap fuel.

A COTTON CENTENARY.

IN 1790 the first successful crop of sea island cotton was raised at Hilton Head, South Carolina. It is now proposed to make the one hundredth anniversary of that event the occasion for the celebration of the centenary of American cotton. As South Carolina was the State in which the above mentioned crop was raised, and as Charleston was the port from which the first cargo of American cotton was shipped, there is a reasonable appropriateness in the selection of the city of Charleston as the place in which the celebration has been held.

Probably very few persons who have not considered the matter attentively realize what cotton has done, and what has been done for cotton, within the century just expiring. The cotton fiber has been known and used for the manufacture of cloth so far back in the ages that the memory of man runneth not to the contrary. It has been spun and woven in India for centuries, and cotton cloth from India has drifted in small quantities to different parts of the world for other centuries. But the cotton fiber did not assume a place of real importance with relation to human existence, and cotton cloth did not even begin to come into general use, until American cotton appeared in the field of industry. Indeed, we may go further than this, and confidently assert that the manufacture of textile fabrics for export upon a large scale from one country to another dates from the introduction of the American fiber to the market; so that it is literally true that the vast textile industry of modern times had its origin in the cotton plant grown and developed upon the soil of our own country. What a mighty revolution in industry has this fiber wrought! When we observe the results it has produced, we may well agree that the centenary of American cotton deserves to be celebrated with honor.

We now export every year three or four times as much raw cotton as the entire world produced when the industry was begun here, and we reserve for home manufacture a larger quantity than was consumed by all other nations until late in the present century. The product of the world in 1791 was estimated at 490,000,000 of pounds, of which the United States produced 2,000,000 pounds. In 1821 the product of the world was 630,000,000 pounds, of which the United States produced 180,000,000 pounds, an increase of 178,000,000, or 38,000,000 pounds more than the increase of the crop of all countries. From 1821 to 1824 the American development was so rapid that in the latter year the crop of the United States was reported to be 460,000,000 pounds, or nearly as much as the product of the world in 1791. Meanwhile, however, the crop of some other countries had materially increased, the total yield being estimated in 1831 at 820,000,000 pounds, and in 1834 at 900,000,000 pounds. It may therefore be asserted that this country now produces six times as much cotton as the rest of the world produced one century ago, while we annually retain for our home manufacture as much cotton as was made up by all nations fifty years ago.

We should like to place especial emphasis upon the fact that while 1890 will be the centenary of the first crop of sea island cotton, it will be the centenary also of the imposition of the first protective duty upon American cotton. In the years preceding 1790, Americans began to perceive that their cotton culture was an industry of importance and promise. This induced them to lay a duty of three cents a pound upon cotton in the tariff act of August 10, 1790. That this protective duty had a great effect in stimulating the cultivation of cotton in our Southern States cannot be questioned, and no doubt we owe to the wisdom of our fathers, in thus fostering the industry, very much of the magnificent supremacy now held by the American staple. It will be not a little odd, and certainly not at all creditable, if we shall be forced to enter upon the centennial year of this important event with the American cotton manufacturing industry prostrated by reversal of the very policy of protection which enabled American cotton growing to begin its career of splendid prosperity.

In this connection it is worth noting that such cotton manufacturers as we had in 1790 were opposed to the imposition of the three cent. duty, upon the theory, made very familiar of late, that their industry could not thrive without free raw materials. They believed that the United States could not produce enough cotton, or cotton of sufficiently good quality, for their purposes, and that they could not compete with India or with England unless they could get Indian or African cotton. It is well to recall such forebodings at this time, when multitudes of Americans are talking about our domestic wool clip in just such a fashion as some Americans a hundred years ago talked about our cotton crop. In the case of cotton, the ultimate result was that we obtained from our own fields all the cotton we required for our domestic uses, and enough to supply all the world besides. And we venture the assertion that persistence in the policy of protecting American wool growers will very soon place us in a somewhat similar position with respect to wool. We shall never, probably, supply the world with wool as we supply it with cotton; but beyond a doubt we may grow all the wool we want for ourselves and have a large surplus for export.

Of course the invention of Whitney's gin gave to American cotton its largest impulse; but then, it must be remembered that Whitney's invention came because the cotton was there, requiring such mechanical aid; and the protection duty produced the cotton and created the demand for the inventor's skill. And this may lead us to show how large a part mechanical invention has played in enlarging the supply of cotton for human necessities. It was the possession of Whitney's gin that helped the United States, with dear labor, to push far ahead of India, with cheap labor, as a producer of raw cotton. It was estimated in 1826 that, if no machinery for making cotton fabrics other than was available in 1790 had then been in existence, about fifty million people would have been required to do what was done in 1826. It is now calculated that the cotton fabrics made at the present time, if made with the appliances available one hundred years ago, would require the labor of three hundred million persons. And the industry makes forward strides every year, so that in a short time its product may be expected to represent what would, without machinery, be the labor of the entire population of the globe. It is noteworthy, also, that increased production has never overtaken the capacity of mankind to consume, and we are confident it never will; but that every improvement, by cheapening the supply while enlarging it, will permit the wider use of the material.—*Textile Record.*

COMPOSITE PORTRAITURE.*

IN the composites I have thus far made, I have merely attended to keeping the vertical distance between the eyes and the parting of the lips at exactly the same length in all cases, and to making the best fit of the remainder that each case severally admitted. It strikes me now that it would be well worth while to vary the whole procedure by attempting to approximate to a mean result, and in the following way. First, find by measuring the portraits about to be combined the proportion that the distance between the pupils bears *on the average of all of them* to the vertical distance between the pupils of the eyes and the parting of the lips; then optically transform every component portrait into that same average proportion. Secondly, straighten every face that is asymmetrical in the way above described, into a symmetrical one. Lastly, make the composite from the transformed portraits.

I suspect that a pinhole camera would be found perfectly suitable for effecting these transformations, if the component portraits were not too small. A portrait of sufficient size could, by a single operation, be reduced by its means to any desired scale, both in breadth and in width, independently of each other, namely, by the ingenious device I saw lately in your columns, but cannot specify where, of replacing the pinhole by a vertical slit in one movable diaphragm and a horizontal slit in another. The asymmetry could at the same time be remedied by so inclining the portrait to the optical axis of the camera as to foreshorten the side that was too long. Foreshortening is accompanied by no blur of image in a pinhole camera.

The sliding adjustments of the camera would have to be graduated, and each portrait measured carefully by laying a glass scale upon it, and using a low power lens. After this had been done, a table calculated once for all for the camera would tell at what graduations of distance and of inclination the portrait should be set, in order to obtain the desired result.

"The transformations I propose are small in amount. They are always made, and we unconsciously witness them, whenever the person at whom we are looking holds his face a little inclined from a full face view. But, small as they are, I think they are worth making. I have not now got my photographic things in working order, and am busied in other ways, so I speak for the most part theoretically; but not wholly so, as I have made some optical experiments which corroborate, so far as they go, the feasibility and advantage of what has just been said.—*Photo. News.*

* A communication from Francis Galton.

[Continued from SUPPLEMENT, No. 649, p. 10365.]

ELEMENTS OF ARCHITECTURAL DESIGN.*

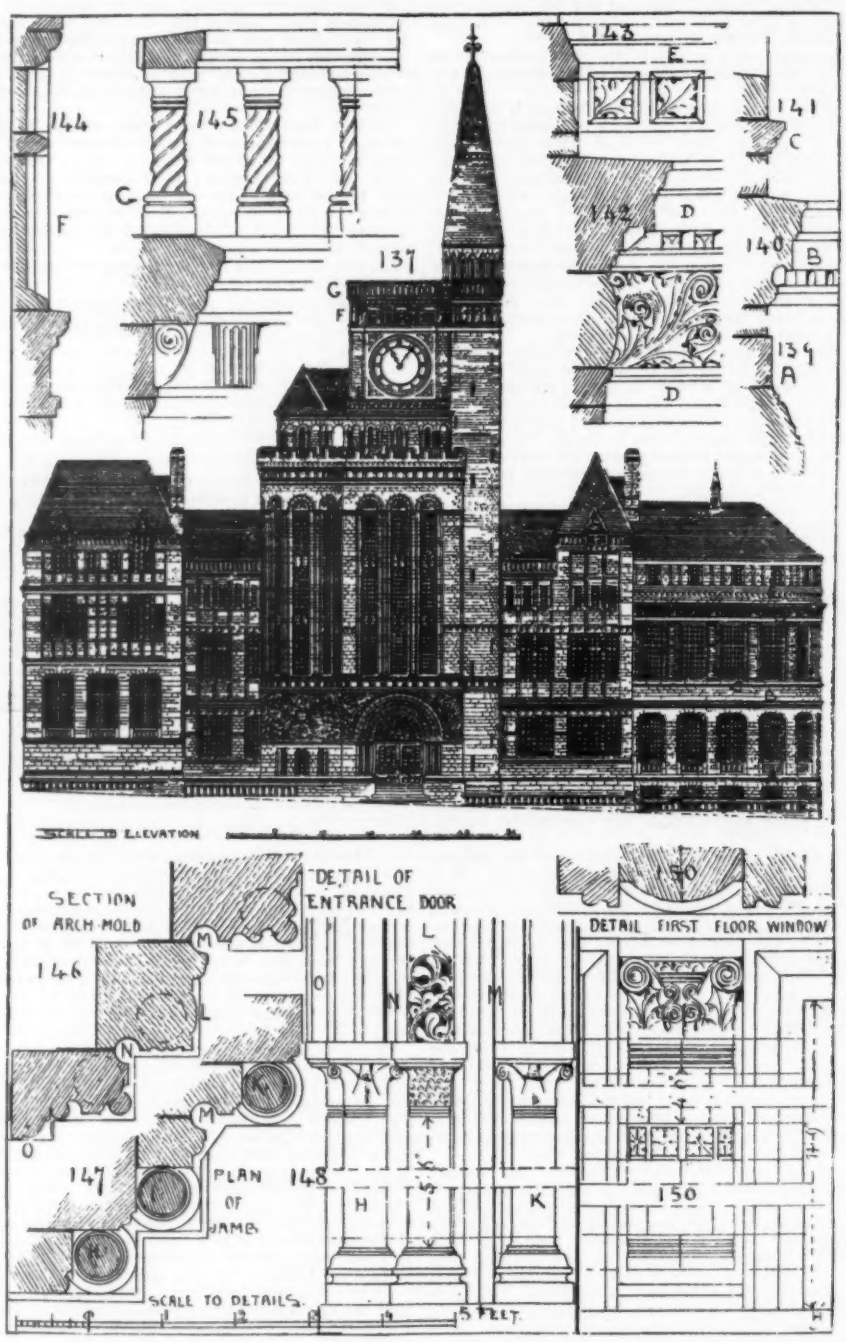
By H. H. STATHAM.

LECTURE IV.—CONTINUED.

THE question has been discussed sometimes, how far ornament can express any meaning or sentiment. As a general rule I think it may be said that it can rarely do this without at the same time ceasing to be ornament in the true sense at all; ornament being essentially something created for the sake of beauty. There has been a certain practical meaning in some ornament, as in the ox head (or skull), and wreaths and pateræ between, which used to be sculptured often on the frieze of a Roman temple, and which symbolized the sacrifices which went on within the temple. This has been imitated in modern architecture without any excuse or meaning at all, these objects not having the same signification for us; the real parallel would be if we sculptured the exterior of a law court with bas-reliefs of judges' wigs with gowns festooned between them, or the exterior of a hospital with an alternating ornament of bottles and bandages; we should then be doing the same thing that the Romans did with their ox head and garland friezes. There have occasionally been fairly successful attempts at giving a half symbolical meaning to architectural ornament. M. Garnier has done this, for instance, in some of the capitals in the Paris Opera House; in one, of which a drawing is shown, the center of the capital is occupied by a very conventional suggestion of a lyre, which spreads out at each side into members which distinctly suggest wings; it is very cleverly done; there is no imitation, but just the hint given to the mind of an idea; but it is only when done in this delicate and reticent manner that such treatment can be a success. This reminds one of that famous Egyptian example, the winged globe, which is a grand suggestion no doubt, but in the way it is generally used in Egyptian architecture it is perhaps more properly termed a symbol than an ornament.

While speaking of architectural detail, it may be of interest to those who have no practical knowledge of architecture to give some idea of the manner in which the detail of a building is shown and worked out in actual practice. To this end I have given a reduction of an elevation which happened to be conveniently to hand (Fig. 137), which will do as well as anything else to illustrate the subject, and shown some of the details to a larger scale along with it. Taking the right wing of the building, there are various horizontal divisions on it marked out by what are mouldings (A, B, C, etc.), but which on the elevation necessarily appear only as groups of lines, indicating the edges of the various members of the mouldings. One of the first things in working out the details of a building is to design the actual profiles of these mouldings, which in practice would be drawn out full size, but here, for considerations of space, they are shown only on a good deal larger scale, in Figs. 139, 140, 141, etc.; the mouldings being identified by the same letters which are attached to them on the elevation. This process would be gone through for every such set of lines shown on the elevation. The cornice, D, is also shown, a small part of it, in elevation, in order to show the design of the carved ornament on the frieze, which cannot be expressed by a section. Similarly, in Figs. 144, 145, the balustrade, cornice, and paneling at G and F on the elevation are shown in detail, in section, and with the distance of the balusters shown in elevation. In drawing details of such portions as doors and windows, it is not necessary to draw the whole out full size or to a larger scale. In Figs. 146, 147, 148, for instance, the whole of the detail of the center entrance is given. Fig. 146 gives the section of the mouldings of the arch, and 147 the plan of the jamb below it, with its three shafts. Fig. 148 is an elevation of these portions, drawn as if standing within the center of the doorway and looking toward the side of it. Part of the ornament at the point L, on Fig. 146, is shown in elevation at L, Fig. 148. The caps and bases of the shafts are shown; the intermediate length of the shaft it is only necessary to mark in figures. In actual practice, the whole door, or its half elevation, half plan (the two sides being alike), and section, would probably be drawn out to a larger scale than the general elevation (say half an inch to a foot, or an inch to a foot)† for greater accuracy in proportioning the parts, and the details shown here would be drawn full size. A similar process would be gone through with other portions; for example, the first floor windows in the right wing, or rather in this case the piers between them, the detail of which is shown in Fig. 150; the plan at the top, and below it the detail of the upper portion, the little bit of ornamental band in the center, and the base; the portions between being figured; a section would also be required, which there is not space to show. Every feature of the *facade* would have to be drawn out and detailed in the same manner; and when it is considered that the detailing of such a front as this would in itself involve about fifty details, mostly full size, not to speak of the other three faces and the multiplicity (probably) of interior details, you will probably recognize that the designing of a large building for actual execution is a somewhat more complicated business than the majority of persons outside the profession of architecture are aware of.

Apart from the decorative detail which forms an integral portion of the building, there is a separate class of what may be called *applied decoration*, consisting of work which is not built up with the building, but attached to its surfaces afterward. Of these forms of decoration the most important and valuable, perhaps, and the most distinctly architectural in character, is mosaic. I call it especially architectural because, being formed by the collocation of innumerable small pieces, there is a kind of character of miniature building about it which assimilates it with the main building. Mosaic cannot be used in positions too near the eye, as a certain distance is required to blend the cubes of which it is composed together, and it is best put together and has the best effect on a concave surface, where it gets varied lights upon it, though it can be used with effect on a flat wall and (of course) on a floor. It is rarely used on convex surfaces, owing partly to the greater difficulty of fixing it in such a position, though it can be done; and mosaic has even been used in ancient, though not in modern, architecture, as a decorative covering to the cylindrical surface of a column, a treatment of which Mr. Poynter has given a representation in his picture, "Diadumene." Marble inlay, a beautiful system of decoration, is a kind of mosaic on a larger scale, put on with larger pieces, and most suitable for a flat surface, though it has been sometimes employed with effect in such positions as the soffits of arches. A method of forming mural pictures of a very permanent kind by an inlay of colored marbles, in large masses, was invented by Baron Triqueti, and some examples are (or were) to be seen at University College, Gower Street; it has a good effect, and is a form of permanent and durable decoration which perhaps merited more attention than it has received. Tiles form another branch of applied decoration, differing from mosaic in this, that each tile is susceptible of bearing a distinct design in itself, which may either be complete in itself and form a repetition pattern by the juxtaposition of the tiles, or may be so arranged that several tiles may work together into a larger repeating pattern. Another form of applied decoration which was a good deal used in Italy in the Renaissance period, and to which attention has lately been directed in this country, is *sgraffito*, which is formed by laying a coat of (generally) black plaster of the usual thickness (but any fairly dark tint will do), and laying on this a very thin coat of white plaster, in which, while still soft, a design is drawn by removing the white where required, leaving a design either black on a white ground or white on a black one. This has the merit of being a form of applied decoration which is cheap, easy to work, and under certain circumstances very effective; but it is not very durable, and in towns is apt to lose a good deal of its effect through discoloration before very long.



In conclusion, passing from the consideration of architecture as the designing and decorating of a building regarded by itself, and apart from its surroundings, there is a wider view to be taken of architecture in cities, which are a collection of buildings forming an architectural group or a series of architectural groups in themselves. In these days, when cities are not founded all at once by the will and command of some omnipotent ruler, but grow up insensibly as a gradual agglomeration of buildings, the disposition of which is defined far too much by accidents of site, we have no chance of doing what would be the grandest form of architectural design that could be undertaken—the designing, namely, of a whole city so as to give the greatest effect of climax to its larger buildings, the finest combination of convenience with picturesqueness in its streets. But this desire for architectural effect in the disposition and grouping of buildings is never entirely dormant. In the life of every city there occurs from time to time a crisis in its development; a time when the old buildings are found deficient and are to be rebuilt on a grander scale, or when this or that quarter of the city is too crowded and a new street is to be opened out; occasions when there is usually some attempt, or at least the pretext of an attempt, to take the opportunity of getting a new and finer effect of architectural combination. In this country the mischief is that these opportunities are either neglected or taken in hand in a faint-hearted, half-and-half manner, and, if we may judge from the results, by persons who either do not care about or do not understand the matter. London is in itself a whole history of lost and wasted opportunities in this respect; in many cases arising from a poor and shortsighted spirit of economy. There was the greatest opportunity that an old city ever had, after the burning of London, and Wren had a grand plan for laying out anew the burned city; but he was not allowed to carry it out, and we suffer from the parsimony of the government of his day, as future generations will suffer for our economies and mistakes. A great many new streets are lined with buildings irrespective of any general consideration of architectural effect, and thus we have perpetuated such dreary and soul-oppressing avenues as Victoria Street and Cromwell Road, the very look of which seems enough to frighten away any one who cares for beauty from wishing to live in them. In matters of detail we are, in London, most curiously neglectful of what the French, who are very attentive to these points, call the *emplacement* of buildings. It would have been quite easy, for instance, to have placed the Albert Memorial on the axis of the Albert Hall, instead of putting it just so much out as to look as if it had been meant to be central, but had been set out wrong by some bungling person. The removal of the Constitution Hill arch recently is another example. I doubt if there was any practical necessity for removing it at all; the way would have been to have carried an inclined plane road

* Delivered before the Society of Arts, London, December 19, 1887. From the *Journal* of the Society.

† The general plans and elevations of a building are in England usually drawn to a scale of eight feet to an inch for buildings of average size, or ten feet to an inch for very large buildings; for comparatively small buildings four feet to an inch is sometimes used: this used to be the favorite scale, but it is inconveniently large for anything above the size of a small house.

from opposite the foot of Park Lane, running *under* the bend of Constitution Hill into Grosvenor Place. But whatever may be thought of that, the manner in which this so-called improvement has been carried out shows an utter want of architectural perception. The arch as it formerly stood made, standing parallel with Apsley House and the Hyde Park entrance gates, a kind of monumental entrance into London from the Knightsbridge Road. It is now facing nothing, grouping with nothing—stands as if it had been built by accident; and for the *place* which has been thus opened nothing better seems to have occurred to the official architectural mind of the office of works than to let the road lines cut the space up irregularly into three shoulder-of-mutton slices. The plan is that of a surveyor's clerk, not of an architect. We are worse off even with our other official authority, the metropolitan board of works. They would have liked to have ruined the portico of St. Martin's to widen a small bit of road, if the rector had not had the sense to stand in their way; they would like to pull down St. Mary-le-Strand, the central architectural ornament of that part of London: it is generally believed that they would pull down St. Paul's if they could make a new street over the site which would be two minutes shorter to somewhere than the road round it. We will spend no proportionate sums over our great buildings. When money is asked for such a building as a war office, instead of there being any desire to do it in a way worthy of a great country, and such as would be a delight and pride to future generations, the cry in Parliament is nothing but economy, economy! and the thing is to be patched up in the cheapest way it can be done, and with no regard to architectural grandeur; while a little kingdom like Belgium, as if to shame us, has spent about a million on law courts for the sake of doing a grand thing, and produced a building which is one of the architectural achievements of the age. This growing indifference and, I should venture to say, stupidity about the architectural treatment of a great city is a sign possibly of something more than architectural indifference: it is an indifference to the greatness and honor of the country. Periods of great architecture have usually been periods of great national aspiration of one kind or another; and when a nation is indifferent to its public architecture, it is only too probable that it is in a "don't care" way in every respect, that it is going down hill, and, as Matthew Arnold says,

"Letting
Slowly die out of its life,
Glory, and genius, and joy."

Leaving the city, the relation of architecture to the landscape in which it stands takes us finally to the last and widest view of the subject of architectural design. There are few provinces of human labor and invention which, if we follow them out to their final consequences, will not lead us into further and more extended relations with the world around us than we dreamed of at starting; and architecture is no exception. We begin with stones and beams, with the placing of a lintel or the turning of an arch, and we end with finding our work a part of nature's scenery, lighted by her passing gleams, darkened by her cloud shadows, or drenched with her rain and storm. The consideration of the effect which the building may have on the landscape, and how the site will affect the building, is one of the most interesting problems in connection with architecture, quite worth a lecture in itself, and far too large to do more than touch upon now; but it is one very much neglected. What is chiefly, I think, to be aimed at in such a case is harmony of tone with contrast of line. Harmony of tone is best secured by using as far as possible the natural building materials of the district, a thing which I think should always be aimed at where it is possible; that is to say, where there are any building materials fit to use. And why contrast of line? Well, partly because you cannot compete with nature; if you are to build among hills, it is no use trying to overtop them or come into competition with them; build solid and level by contrast with them. Illustrations of this feeling for contrast may be found both in actual buildings and scenery and in the works of great landscape painters. Among the mediæval churches the great spire-building districts are in the flat countries, such as Lincolnshire, where the spire derives additional value by contrast with the level lines of the landscape from which it rises, and over which it is seen for many miles. Few great spires have been built among hills. The Greeks placed many of their temples, especially the Doric temples with their square masses and long level lines, among broken and rocky scenery, if not from the conscious intention of contrast, at least with an intuitive feeling for it. Mr. Herbert Spencer, indeed, in an essay upon this subject, has maintained that a picture of a Greek temple amid rocky scenery has an appearance of incongruity, and is not truly picturesque; but it is clear the Greeks who built the temples were not of this mind. Their greatest Doric temple, the Parthenon, is seated on the top of the rocky crag of the Acropolis. A lofty, spire-like building would be out of place in such a situation. There is a striking design of Turner's (among the *Liber Studiorum* I think) showing the spire of Salisbury cathedral rising across the horizontal line of a long low hill which actually exists near Salisbury (Turner would have had no scruple about inserting the hill if it had not been there, but as a matter of fact it is there), with the obvious intention of increasing the "value" of the spire by contrast with the horizontal line of the ridge of the hill. I give a sketch of an actual scene in which a house which is but an ordinary piece of architecture in itself is made to give a special accent and character to the scene by being placed on the very point where the landscape seems to require such a feature, so that the landscape and the building both gain in effect by the combination.* Two sketches of old Scotch castles (from Billings' well known work on the subject) serve to illustrate the harmony of massive square buildings with rocky landscape. In one case the massive block of the castle rises straight off a level lawn, and appears quite out of keeping with its situation. The other, the grand castle of Borthwick, with its double towers, stands on the highest point of a rocky eminence, and seems exactly the building for the situation. A fine example of Turner's illustrates a painter's idea on the subject in rather a different manner. This is the fine picture of Conway Castle, now (January) in the Grosvenor gallery. Here the castle stands as a dark square mass in the middle distance of a flat stretch of land. Turner evidently felt that in this situation the castle, which it was his object to emphasize, would not in itself tell sufficiently; accordingly, he has built up behind it a rampart of clouds in square masses repeating to a certain extent the lines of the building, and thus given it a mass and grandeur of effect which, owing to its position, it would not otherwise have had. Perhaps one of the most interesting and fascinating tasks which the architect could have, but which for financial reasons he cannot hope often to have, is when, having built a great mansion in the midst of a fine landscape, he can proceed gradually to connect it architecturally with the landscape itself, by a treatment of the gardens and immediate surroundings with architectural formality in the neighborhood of the house, and gradually decreasing the symmetrical and architectural character of the surroundings until the design, as it were, resolves itself into and blends with the surrounding landscape. This may be called "landscape gardening;" it is unfortunate that it is too often no more than this, but it is a task entirely within the proper scope of architecture, and when successfully carried out it gives the last touch of interest to the architectural design, which is not to be a blot or an intruder in the landscape, but rather to give it the higher interest arising from the expression of human life and human intellect.

*This and the other sketches referred to were placed on the walls.

NEW AUTOMATIC FIRE ALARM.

A NEW automatic fire alarm, based upon the expansion of air, is being introduced by the "Patented Appliances Company," and is shown in the adjoining cut (Fig. 1). It consists of an air chamber hermetically

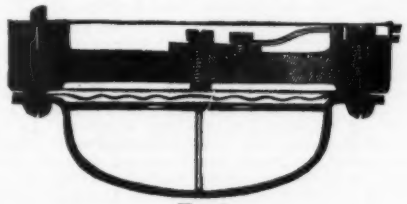


FIG. 1.

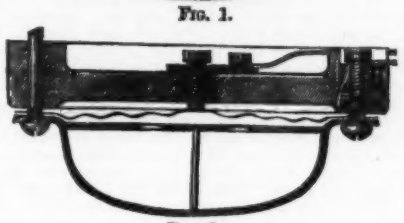


FIG. 2.

closed by a corrugated metal plate, similar to that used for an aneroid barometer. When the temperature rises to a certain point, the expansion of the contained air brings the metallic plate in contact with screw, as shown in Fig. 2. This closes an electric circuit, which rings a bell, and operates an indicator in the usual manner.—*The Electrician.*

SAUNDERS' LIGHTNING GUARD.

WE mentioned, says the *Electrician*, a recent instance in which a lightning flash struck the cable station at Porthcurno and fused the coils of two recorders, the only lightning protector in the station which proved efficient being one of the form devised by Mr. Wm. Saunders. Under these circumstances this form of protector is likely to come into more extended use, and the following description will therefore prove of interest. The Saunders lightning guard consists of a brass tube, B (Fig. 1), through which passes a fine wire, W, one end of which is attached to the terminal, C, and the other to a stud passing through and moving freely in the terminal C'. The spiral spring, S, is held in tension by the wire. The consequence is that when the fine wire is fused by lightning, the spiral spring, S, is released, and the stud makes contact with the screw, E, which with the tube is connected to earth, thereby putting the cable to "earth." The plugs, A A, at each end of the tube are for the purpose of bringing the line and "earth" as near together as possible. They are shown separately in Fig. 2, which also gives a transverse section of the instrument.

All the parts are mounted on a vulcanite base—to give good insulation between line and "earth," etc.—covered with a glass top case.

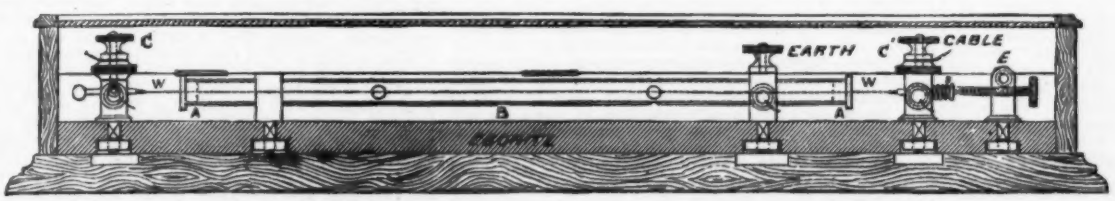


FIG. 1.—SAUNDERS' LIGHTNING GUARD.

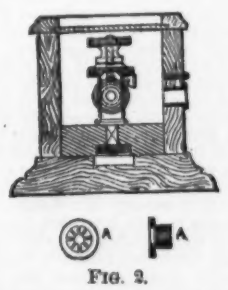


FIG. 2.

INSTRUMENTS FOR RECORDING AND REPRODUCING SPEECH.

PROF. ALEXANDER GRAHAM BELL read, at the last meeting of the Fortnightly Club, a paper upon recent inventions for recording and reproducing speech, exhibiting, to illustrate what he said, some of the latest and most curious devices that have been produced. He explained the nomenclature of the subject as he thought it ought to be used, by saying that a phonograph is an instrument for making a record of speech; phonogram, the record so made; and graphophone, an instrument for reproducing speech from a phonogram. In some cases the phonograph and graphophone are the same in most of their parts, but in many they are entirely different.

Prof. Bell exhibited the graphophone, of which a number are now in practical use, and which, in its essential parts, is similar to Edison's phonograph. The record is made on a cylinder covered with wax or paraffine, and the speech is reproduced by conducting the sounds to a diaphragm connected to an open trumpet-shaped instrument, or, by wires to devices placed upon the ears, vibrations corresponding to those that were produced when the record was made.

A modification of these instruments was shown, in which the record was made upon a pasteboard disk revolved upon a shaft in a horizontal plane. The upper surface of the disk is covered with wax, upon which a similar impression to that on the wax-covered cylinder is made by a stylus connected with a diaphragm which is caused to vibrate by the sound of the voice. The record is a spiral groove cut in the wax. The reproduction is obtained in a manner similar to that used in the cylindrical machine. The principal advantage which this form of the instrument is expected to present over the older, cylindrical form is in the greater facility of multiplying copies. Electrotypes are much more readily made from the flat disks than from the cylinders. From these electrotypes other disks covered with wax, and that with tin foil to prevent sticking, obtain the spiral impression by pressure of the former upon the latter; and when one of these duplicates, the tinfoil having been removed, is put into the instrument, the reproduction of speech is as perfect as from the disk on which the original record was made.

The most interesting and curious part of Professor Bell's paper related to experiments based upon investigations and discoveries made by Dr. Chichester Bell in regard to the effects of sounds upon jets of fluid. It is well known that if a jet of fluid, like water, is placed in sound waves, it is not only sensitive to them, but it reproduces them as the string of a musical instrument, tuned in unison with that of another, will vibrate, and reproduce the tones given out by the first. It is not easy to hear the sound or speech reproduced by the jet of water. The former mode was to connect the hearing tube with a rubber diaphragm placed in the jet of water, which is discharged perpendicularly from above, at a given pressure, from a very small orifice. When the rubber is held very close to the orifice, the sound reproduced is very faint; but, as it is moved away, it increases in volume until the point of maximum loudness is reached; then it diminishes again until near the point where the stream begins to break; and then it is broken up, and is entirely unintelligible. As the sounds to be reproduced by the jet have to be made in the same room, and very near to the jet of water, it is very difficult for any but a practiced ear to detect the one from the other.

In order to make this more satisfactory, Dr. Chichester Bell made the following experiment. Substituting two platinum wires for the rubber diaphragm with a small piece of some non-conducting substance inserted between their ends, he placed this in the jet at the point where the largest volume of sound has been found to be reproduced. These wires being connected with an electric battery, and a telephone placed in the circuit, it was possible to have the speaker and listener almost any distance apart. With this apparatus, speech was not only reproduced, but with increased volume; the jet of water not only spoke, but acted also as a microphone to magnify the sounds it made.

Upon these experiments were based those which Professor Bell explained to the club. The jet of water, somewhat colored, was discharged upon a glass plate placed in it at the point from which the greatest volume of sound was known to issue in reproducing speech. This caused the jet to spread out in a thin film over the plate. The under side of the glass was covered with an opaque substance in which there was a small slit through which a small amount of light could pass. Behind the slit a moving piece of photographic paper was placed, upon which the record was made. Then a person spoke over the plate, and the result was a very curious line upon the photographic paper. When this line was transferred to gelatine in the ordinary way, it was found that a series of elevations and depressions was produced, which could be felt with the fingers, and from which an electrotype could easily be made. This showed that the sound waves, striking the film of water on the glass, caused constant changes in the thickness of the latter, and thus caused a variation in the intensity of the light that passed through the slit. From such a record as this, it will probably be a simple problem to reproduce the speech. Professor Bell exhibited specimens of the original record upon the photographic paper of the negative that is made for the transfer to the gelatine,

and of the gelatine after the transfer had been made. The possibility of developing from these experiments an instrument for the reproduction of sounds that may be superior to any yet made is what makes them so interesting.—*Science.*

ORIGIN OF THE NAMES OF MINERALS.

IN a recent number of the *American Naturalist*, Mr. Endlich endeavors to trace out the names of minerals, over the nomenclature of which no rule has presided.

The etymological source of a large number is easily derived. The roots of the words are borrowed from the Greek or Latin languages mainly, sometimes from German or Swedish, and designate one of the chemical or physical properties—if not characteristic, at least remarkable—of the mineral in question. Among such names are: barytes, from *βαρυς*, "heavy;" euclasite, from *εὖ*, "well," and *κλάω* "I cleave;" tungstite, from Swedish *tung*, "heavy." Others owe their name to the modifications that they undergo under the influence of heat; for example, scolecite, from *σκόληξ*, "worm," because when this mineral is exposed to heat it exfoliates, and twists like a worm. The zeolites, from *ζέω*, "I boil," are minerals that exhibit a genuine ebullition at the moment of their fusion.

But, besides such names, the explanation of which is easy, there are others whose selection can be understood only by the aid of historic data as to the circumstances that accompanied their discovery. Thaumasite, automolite, and æschynite may serve as examples of designations of this kind. Nordenskjold, having discovered the presence of a mineral which, according to preconceived ideas, ought not to have been met with in such a case, called it thaumasite, from *θαυμάζω*, "I am surprised." Automolite, from *αὐτόμολος*, "deserter," was thus named by Ekelberg because this body formed by separating from a composition that he thought to be clearly determined. Finally, the name of æschynite, from *αἰσχύνη*, "shame!" recalls Berzelius' protest against the chemists of the epoch (1828), who could not separate the zirconic and titanic oxides.

The etymology of the names of the best known minerals is often very obscure. Thus, quartz, designated for the first time in Agricola in 1546, has been variously derived from the words *quarry* (Engl.), *quadrus* (Lat.), *quader* (Ger.), *quaterstein* (Swed.), which all relate to the cutting of stones. Another hypothesis is that it is from the word *quartatio*, "separation," because the crystals, in forming, separate the other stones from the metals. Muller supposes the word to stand for the German *gewarz* (=*warz*), "wart," from the excrescences upon the mineral. We find the same trouble to explain the word antimony. Is it from the Greek *στιμμι* (sulphide of antimony, now called stilbite), or from Arabic *al ithmidum*, the syllable *an* being a modification of the definite article *al*? A curious etymology is that which connects it with the operations of Basil Valentine, a German Benedictine monk, who led the way to the internal administration of metallic antimony by a variety of experiments on the nature of the metal. Tradition has it that, having observed that the compounds of antimony fattened hogs, he was led to extend his experiments to his brother monks, all of whom he injured, if not killed. Those who have keen ears for sounds will at once recognize in this circumstance the origin of the word, viz., from *ἀντί-μοναχος*, "against-monk."

NOTES ON AMERICAN FOUNDRY IRON.*

THE iron-making resources of the United States of America have so largely increased during the last few years that English iron makers can scarcely afford to look on with indifference while their cousins across the Atlantic are making such rapid progress. Thus, taking the years 1885 and 1886, the production of pig iron in the two countries is returned as follows:

	1885. Tons.	1886. Tons.
United States	4,529,869	6,365,328
Great Britain	7,415,469	7,009,745

The returns obtained from different sources show some variations, but so far as the purpose of the present paper is concerned, the numbers given may be accepted as correct. It should be mentioned that the quantities for the United States are returned in metric tons of 2,000 lb., but, even with this allowance, the figures are sufficiently startling, for, while Great Britain shows a decrease of 406,724 tons, or rather over 5 per cent., the United States on the other hand increased its production by 1,835,459 tons, or rather over 40 per cent., and this increase was well maintained during 1887, the output last year amounting to no less than 7,187,206 metric tons.

The following notes were suggested by the collection of a set of specimens, prepared by Mr. Keep for the metallurgical department of the Mason College, and intended to be used for teaching purposes. The memoranda accompanying them were not originally intended for publication, or possibly irons might have been selected which would have shown American production in a somewhat more favorable light. But as such a collection is probably the most representative one in this country, and as the information is very complete, it has been thought well to publish it. The irons shown were selected from the collection in the physical laboratory of the Michigan Stove Company, Detroit, of which company Mr. Keep is superintendent. The collection is not intended to show the irons actually used by the Michigan Stove Company, but to illustrate average American foundry iron. These specimens are especially valuable from the fact that in most cases they are samples of the identical irons of which a most complete series of physical tests has been performed, and of which the chemical analysis is known. In a continuation of the present paper Mr. Keep will give details of these tests.

In Great Britain the fuel employed in the blast furnace is almost invariably bituminous coal or coke, but in the United States large quantities of pig iron are produced from anthracite and from charcoal, as shown by the following figures:

Fuel Used.	No. of Furnaces in Blast Dec. 31, 1887.	Production in 1887. Metric Tons.
Anthracite	118	2,338,389
Charcoal	74	578,182
(Coal and coke.) Bituminous	147	4,270,635

Michigan produced more charcoal iron in 1887 (213,543 tons) than any other State, while Alabama followed with 95,223 tons. The largest production of any single State is, of course, that of Pennsylvania, which stands far away ahead with 1,929,777 tons of anthracite iron, 1,742,931 tons made from bituminous fuel, and 11,910 tons from charcoal. The State showing greatest activity in furnace building last year was Alabama, with twenty new furnaces in course of construction. The six States having the largest production stand in the following order:

	Tons.
Pennsylvania	3,684,618
Ohio	975,539
Illinois	565,453
New York	296,572
Alabama	292,762
Tennessee	250,344
Michigan	213,543

The meaning of these figures will be better understood when we remember that the production of pig iron in the Cleveland district in 1886 is returned as 2,406,276 tons, while South Staffordshire produced only 236,137 tons. Ores of good quality occur throughout extensive districts in the United States. The specimens now shown are intended to illustrate only the irons produced at some of the most important points, and from the principal ore formations. These ore deposits are: (1) The great deposit of magnetic ore beginning on Lake Champlain in northern New York, and running southward through that State into New Jersey, and still southward to North Carolina, also the brown hematites which accompany this deposit. (2) The great deposit of red fossil ore, running about one hundred miles west of the previous deposit, beginning in central New York, running through Pennsylvania, and southward to the immense beds of Alabama. This deposit also has contiguous brown ores. (3) The carbonaceous ores of Kentucky and Ohio. (4) The unlimited ore deposits of Lake Superior.

In this brief survey we cannot even speak of numerous other very important deposits, such as those of Missouri, where Pilot Knob and Iron Mountain are of solid ore, or the brown hematites of Tennessee, or the deposits of Wisconsin and other districts. In these instances the ores are chiefly smelted with charcoal. In the case of the great Southern ore deposit, the ore and coal lie in the same hills, and hence need no transportation, but very frequently in the United States fuel is transported to considerable distances. In other cases ore is carried, while sometimes ore and fuel are both transported to some intermediate locality. In Eastern Pennsylvania are the great anthracite coal fields, which are reached by a complete system of canals and railways from the Hudson River. In Western Pennsylvania are immense bituminous coal formations, from which excellent coke is made. In Ohio is found block coal, which can be used raw in the blast furnace. In Alabama the best of coking coal occurs with the ore. The chain of great lakes—the St. Lawrence River, Lake Champlain, and the Hudson River, with canals and railways—give facilities for cheap transportation of Lake Superior or Lake Champlain ores to the coke of Western Pennsylvania, to the anthracite of the eastern portion of the same State, or to the coals of Ohio. On the other hand, when necessary, the fuel may be cheaply conveyed to meet the ore.

Poughkeepsie Irons.—This may be taken to illustrate the irons made from the magnetites of northern and southern New York, and the brown hematites on the east side of the Hudson. The fuel used is anthracite coal. Poughkeepsie is on the Hudson River. The furnaces are of the older type, 60 ft. high with 16 ft. boshes. Temperature of blast about 1,100 deg. F., pressure 8 lb. per square inch. The ores employed are used in equal proportions, thus: one-third magnetic ore from Mineville, Essex County, N. Y. (Lake Champlain ore); one-third magnetic ore from Fort Montgomery, Orange County, southern N. Y.; one-third brown hematite ores from the Sylvan Lake, Beekman, and Clove Valley, Dutchess County, N. Y. These ores have approximately the following composition:

	Metallic Iron.	Silica.	Phosphorus.	Oxide of Manganese.
Lake Champlain	67·19	1·14	0 84	....
Fort Montgomery	61·95	7·90	0·24	....
Sylvan Lake	51·02	8·51	0·06	trace
Clove Valley	49·04	11·95	....	2·71

Beekman resembles Clove, but contains less manganese. The limestone used is taken from the bank of the Hudson River, and the furnace charge yields about 55 per cent. of metallic iron. As illustrating the regular working of this furnace, we may mention that in 1870 Mr. Keep made a memorandum of what he saw charged while spending a day at the works, and this exactly corresponds with the above record of what is used at present. The iron is graded as No. 1 and No. 2 foundry, No. 3 gray forge, and No. 4 mottled. They endeavor to make entirely No. 1 foundry, and other grades come from various changes in furnace working. Mottled is seldom made. Analyses of the iron are as follows:

	Carbon.			Si.	P.	S.	Mn.	Iron.
	Total.	Graphitic.	Combined.					
No. 1 foundry	4·24	....	....	3·01	0·15	0·05	1·46	90·64
No. 3 gray forge	....	....	....	1·17	1·63	0·15	1·03	91·96
No. 1 foundry	3·266	3·166	0·100	2·946	1·242	trace	0·189	.....
No. 2 foundry	3·572	3·457	0·115	1·842	1·224	0·035	0·241	.....

The first two of these analyses were supplied by the furnace company. The last analyses are of pigs from the same stock pile as that from which the pig was taken for physical tests, to be described in our next paper.

• *Bushong Iron.*—This sample illustrates the production of the Keystone Furnace Company, of Reading, Pa., situated in the heart of the anthracite coal region. The ore mixture consists of one-third brown hematites, obtained near the furnace, with two-thirds of magnetite, principally from New Jersey and Lake Champlain. The iron is graded A1, B1, No. 2 plain, and gray forge. They run on A1, but sometimes get off on lower grades. A pig from the same pile as the pig used for physical tests had the following composition:

NO. 1 BUSHONG.

Carbon	Total	3·343
	Graphite	2·879
	Combined	0 464
Silicon		1·932
Phosphorus		1·089
Sulphur		0·013
Manganese		0·136

Red Fossil Hematite Irons.—The collection includes two samples intended to illustrate the great red fossil hematite formation—one from the Franklin furnaces of Clinton, Oneida County, N. Y., situated at the extreme northern end of the formation, the other from the Alice furnaces of Birmingham, Alabama, at the extreme southern limit of this ore deposit. The Franklin furnaces use anthracite coal from Pennsylvania. The Alice furnaces are fitted with modern Whitwell stoves, and doubtless work hotter and more rapidly. At both localities two veins of ore occur, one hard and the other soft. At Clinton the soft ore is 1 ft. thick, and has been abandoned. The hard ore now used is 2 ft. thick. In Alabama both hard and soft ore are used, and occur in beds from 20 ft. to 30 ft. thick. In most cases the ores are self-fluxing. The following are examples of analyses:

	Clinton Soft. (Abandoned.)	Clinton Hard. (Used.)	Alabama Hard.	Alabama Soft.
Metallic Iron	30·08	47·50	36·00	50·00
Silica	29·72	11·20	8·00	18·00
Alumina	4·13	4·89	..	....
Lime	8 57	5·53	38·00	...
Manganese	0·31	0·10	trace	trace
Phosphorus	0 67	0·53	0·42	0 70
Sulphur	0·837	0·18	....	....

The analyses of the irons were as follows:

		No. 2 Franklin.	No. 2 Alice.	No. 1 Rising Fawn.
Carbon	Total	3·179	2·963	4·233
	Graphite	3·064	2·742	3·981
	Combined	0·115	0·221	0·252
Silicon		3·014	4·853	1·736
Phosphorus		1·433	0·597	0·828
Sulphur		0·007	0·010	0·018
Manganese		0·168	0·199	0·012

The physical tests of Franklin and Alice iron, to be referred to in a subsequent paper, were made from the same stock pile as the above. This specimen of No. 2 Alice is not a fair sample of the iron usually made. It was sold for, and appeared like, a close No. 2, but both physical and chemical tests show it to be a silvery iron. High temperature, with rapid running, has given high silicon and low carbon, while pure ores have produced a low phosphorus. An analysis is also given of iron from the Rising Fawn furnaces in the northwest corner of Georgia, said to be from a No. 1 pig. This shows more time given for carburization, hence the production of an open grain. In this case also the silicon is rather low. We should say that the silicon in Southern irons would usually run between the extremes above given, generally being nearer the lower than the higher value. The manganese in Southern irons is very low, and they show but slight tendency to chill.

Dayton Iron.—The collection of specimens illustrating the production of the Dayton Coal and Iron Company, of Dayton, Tenn., are of special interest, not merely on account of the completeness of the series exhibited, but also because a complete series of physical and chemical tests are at present being conducted on these irons by Mr. Keep and Mr. H. S. Fleming, and of these tests we hope at a future time to give some account. The samples were selected with special care by Mr. H. S. Fleming (who is now superintendent of Mayville Furnaces, Wisconsin) while he was chemist to the Dayton company. The ore mixture remained the same while the samples were taken, and was much the same as that of the other Southern furnace previously mentioned, except that a little brown ore is used. Owing to the needs of their trade at Dayton, they make an iron which is slightly higher in phosphorus than most other Southern furnaces. The grading is strictly in accordance with the practice of Southern furnaces. It will be noticed that the highest grade is No. 2 foundry. This is a peculiarity of Southern grading, though a Southern No. 2 compares favorably with a No. 1 from many Northern furnaces. In the South the furnaces are generally of the modern type, with Whitwell stoves, and run so hot and so rapidly that the grain is a trifle close, and the color light, when compared with the No. 1 from the older furnaces. An old furnace at Birmingham, Alabama, running more slowly, but using the same ores, makes as dark and open a No. 1 pig as any of the Northern iron, and shows a high percentage of carbon. This illustrates the difference caused by various methods of furnace working. In the South there are large beds of red ore now opened, and which will shortly have railway facilities. They yield 59 to 62 per cent. of iron, 6 to 8 per cent. of silica, and 0·25 per cent. of phosphorus, with practically no manganese. It will be seen that

* Paper read by W. J. Keep, C.E., and Thomas Turner, Assoc. R.S.M., on 10th March, 1888, before the South Staffordshire Institute of Iron and Steel Works' Managers.—*Industries.*

this is nearly a Bessemer ore. The Southern brown ore contains about 0·68 per cent. of manganese, with 0·27 per cent. of phosphorus. On account of this composition, brown ore is used alone in Southern charcoal furnaces to produce a chilling car wheel iron. Southern irons are produced cheaply, and on account of their low price have a considerable influence on the iron market of the United States. Hence we have given a somewhat lengthy account of them.

Irons from the Carbonaceous Ores of Ohio.—These ores occur in northeast Kentucky and southeast Ohio, and from a village in the center of this region, where the ores were first used, they obtain the name of "Hanging Rock ores." They are also called limestone ores, not because they contain limestone, but because they are found upon a limestone bed rock. These ores produce an iron high in silicon, sometimes as high as 6 per cent., and in the market such irons take the name of "softeners." We have selected two samples of such irons, "Wellston" and "Globe." The samples of Wellston irons are specially interesting. Specimens might have been forwarded of iron from other furnaces, which would have been at least as representative of the district as Wellston irons. But this collection is pretty complete, and was selected by the superintendent of the furnaces, while the ore mixture remained the same. The specimens illustrate the grading and characters of these pigs, and physical tests have been performed on these irons which will be recorded in our next paper. Special interest is attached to Ohio silicious irons, because for the last twenty-five or thirty years this class of iron has, to a limited extent, served the purpose for which silicon pig is now used in England. Now that the reason for such practice is better understood, the use of silicious iron is spreading in America, and as Ohio softeners are generally low in other impurities, the silicon is thus obtained in such a form that it acts beneficially on the other irons in the foundry mixtures. Silicious irons are not used in all parts of the United States, as Eastern irons have generally enough silicon in them already. But in those localities where silicious pigs can be easily obtained, irons can also be easily and cheaply procured, either from the rich Lake Superior ores or from the South, which have hitherto been rather too low in silicon for foundry purposes. With the newer furnaces we may expect the Southern irons to be more silicious. The fuel used for the production of much of this high silicon iron of Ohio and Kentucky is a mixture of two-thirds raw coal and one-third coke. An analysis of the coal used at the Wellston furnace is as follows: Water, 11·26 per cent.; volatile matter, 28·96; fixed carbon, 55·59; phosphorus, 0·71; ash, 3·46. The limestone used at the same furnace contained: Carbonate of lime, 93·03 per cent.; silica, 1·51; sulphur, 0·02. The limestone ores, which are of the "Hanging Rock" class, are used roasted. Partial analyses of samples are as follows:

	I.	II.	III.	IV.	V.	VI.
Silica	13·61	15·40	26·22	17·90	25·39	25·89
Alumina	3·00	....	0 68	.....	....	5·16
Lime	2·90	.....	5·24	.....	1·25	.....
Sulphur	0 34	.....	0·11	.....	0·73	0·082
Phosphorus	.....	0·36	0·18	0·29	0·17	0·488
Metallic iron	39·02	27·00	42·93	49·76	.....	41 62

Some old analyses from another furnace using a mixture of the identical ores mentioned above may serve to illustrate the grading and characters of these irons:

	Al Gray Foundry.	Strong Mill.	Weak Mill.	Hard Silvery.	No. 4 White.
Graphitic carbon	2·576	.....	2 59	.....	.. ..
Combined carbon	.....	.....	0·16	.....	1·822
Silicon	6·671	2·589	3·924	5·063	6·655
Sulphur	trace	0·091	0·083	0·048	0·083
Phosphorus	0·503	0·798	0·547	0·755	0·643

Manganese not estimated, but probably under 0·5 per cent.

The physical tests of Wellston irons, which will be referred to in our next paper, are very interesting, and it is intended to perform analyses of these samples when opportunity offers. The grade of these silicious irons can, of course, be varied at will by alterations in the quantity of limestone and of the heat of the furnace. Globe iron is from the same district. The sample exhibited is a No. 1 pig, and has the following composition:

Carbon	Total	3·154
	Graphitic	2·852
	Combined	0·302
Silicon		5·899
Phosphorus		1·100
Sulphur		0·02
Manganese		1·00

A pig from the same stock pile was also tested physically, and the results will be given in the second part of this paper.

Irons made from the Ores of Lake Superior.—In concluding this very incomplete account of the foundry irons of the United States, we take samples made from the great ore deposits of Lake Superior. Among the specimens exhibited is a collection of the grades of iron made at the Spearman furnace, situated in Western Pennsylvania, near to the well known Connellsville coke district. The ore used is purchased, and is not confined to a definite mixture, but consists chiefly of hard and soft Lake Superior ore. Many furnaces in this district use some 25 per cent. of Lake Champlain ore to give a more neutral mixture. The specimens shown may be considered to fairly represent the product from the large number of furnaces which are situated near the coke, and which purchase their ore. This is obtained either wholly or in large proportion, as the case may be, from the deposits of Lake Superior. There is also a very interesting collection of examples of iron made from Lake Superior ores and smelted with charcoal at the Gaylord furnace, Detroit, Michigan. Several of these specimens have been analyzed by Mr. Fleming, and his results are as follows:

	Silicon.	Phosphorus.	Sulphur	Manganese.	Iron.
Gaylord No. 2 foundry	1·570	0·240	0·041	.....	94·283
Gaylord No. 3 foundry	0·809	0·144	0·056	.....	94 088
Gaylord white	0·186	0·263	.....	0·092	.....

It will be seen that these irons are of exceptional purity, and may be considered above the average for foundry purposes. They are used chiefly for special purposes, such as the manufacture of car wheels.

[NATURE.]

CLASS EXPERIMENTS.

THE following is a brief account of some experiments shown to the students of the natural philosophy class in the University of Glasgow during the present session. It is communicated to *Nature* with the permission of Sir W. Thomson.

I. 1. Suspend a heavy ball by a long wire, as shown in Fig. 1. To the middle of the ball attach a worsted

FIG. 1.

thread, AD. Pull the thread in the direction of the arrow head, with a pull that will not break it, and let the pull be finished before the ball is sensibly displaced. Observe the greatest subsequent displacement of the ball.

2. Bring the ball to rest. Pull it now with a pull sufficient to break the thread. Note that the displacement is smaller than in case 1.

3. Bring the ball to rest, once more. Give a very sudden pull to the thread: it breaks, and the displacement of the ball is hardly perceptible.

In each of the three cases the momentum is equal to $\int F\,dt$ for the whole duration of the pull. The pull in case 1 is smaller than the pull in cases 2 and 3, but the duration of the pull is greater in a greater ratio; hence the momentum communicated, being the time intregal of the pull, is the greatest for case 1. Although the pull in case 2 is equal to the pull in case 3, still its duration is so exceedingly small in case 3 that the momentum communicated is very small.

II. Support a cylinder with a fly wheel, as shown in Fig. 2. E E are two pieces of wood, both screwed at

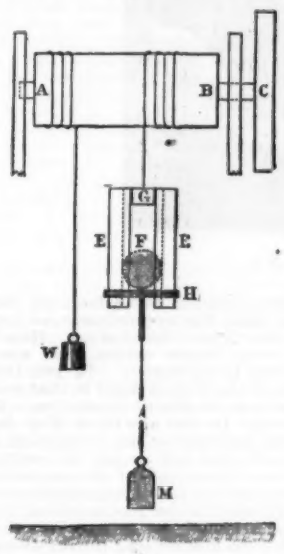


FIG. 2.

the top to another piece of wood, I, of convenient thickness. Each has a slot cut along its center, in which fits a ball, F, to which is attached a stiff wire, a string, and a weight, as shown in the figure. H is an India rubber band, which presses E E together with a pressure at least sufficient to cause the ball, F, not to slip when the weight, M, is hung on to its string. Another string is wound round the end, A, of the cylinder, and a weight attached to it so as to balance the weight of the two pieces of wood, E E. The fly wheel has a friction brake upon it, and if the retarding force of the brake be constant, the angular displacement of the fly wheel is proportional to the square of the momentum communicated.

1. Lift the weight, M, a distance of about half an inch, and let it fall. The cylinder goes round through a certain angle, and the ball, F, is not pulled out of its slot.

2. Lift the weight, M, through 2 or 3 inches, and let it fall. The ball, F, is pulled out of its slot; the cylinder goes round, but through a smaller angle than in case 1.

3. Let the weight, M, fall through a height of 4 or 5 feet. The ball, F, is pulled out of its slot, and the angular displacement of the cylinder is barely perceptible.

The same explanations are applicable to the results of II. as were made concerning the results of I., provided couple be substituted for force, and moment of inertia for mass.

III. The following, though somewhat inconvenient as a class experiment, illustrates the same subject. Fix up a plain deal or other board in the manner of Robins' ballistic pendulum. From a rifle with a small charge of powder, fire a bullet into the board, at right angles to its plane, and as near as possible to its center

FIG. 3.

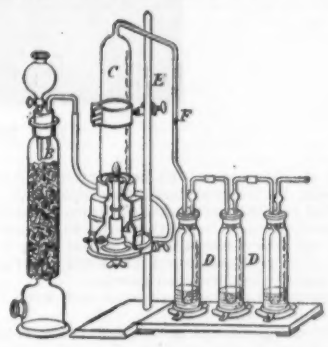
of inertia. The bullet lodges in the board, which is deflected through a large angle. Increase the charge of powder, so that the bullet pierces the board. The deflection of the board is now smaller. Put the maximum charge of powder in the rifle, and the deflection of the board on firing the bullet into it is exceedingly small.

IV. Suspend a light ivory or other ball by a long India rubber thread several feet long, as shown in Fig. 3. Pull the ball into the position, A B', and let it go. Looking at it as seen in the figure, it first begins to describe a curve against the hands of a watch. After two or three periods it begins to go round in a direction with the hands of a watch.

Bring the ball to the position, B', again, and project it at right angles, or at any angle, to the plane, B A B. The ball now illustrates three-dimensional motion. The period is slow, and the experiments are very interesting and instructive. MAGNUS MACLEAN.

A NEW APPARATUS FOR THE DETERMINATION OF SULPHUR COMPOUNDS IN COAL GAS.

A RECENT number of the *Journal des Usines a Gaz* contained a description of a new apparatus, devised by M. Drehschmidt, for the purpose of determining the sulphur compounds in coal gas. The products of combustion from a gas flame are caused to bubble through a solution of carbonate of potash, which absorbs the sulphuric acid, and this is afterward determined in the usual manner, by acidulating with hydrochloric acid, boiling, and precipitating with an excess of barium chloride. The apparatus, as shown by the annexed illustration, comprises a cylindrical casing, A, in which the gas burner, of the ordinary Bunsen type, is inclosed. The air supply necessary for the burner is first purified from the possible presence of sulphur by passing through the glass tower, B, packed with pumice stone kept moistened by potash solution, which is supplied in regulated quantity, by means of a glass tap,



from the globular vessel shown, and connection is made with the top of B and the lower part of the vessel, A, by means of India rubber tubing. On the top of A is fitted a glass cylinder, C secured air-tight by means of an annulus filled with mercury, in which the lower edge of the cylinder is immersed. A and C are held in position by screw supports attached to the stand, E. The carbonate of potash is contained in three bottles, D, which are similar in construction. In order to secure a thorough division of the gas, the inlet tube is enlarged, and closed at the bottom with the exception of a number of very minute perforations. A small bulb is added on the outlet tube of each bottle, to receive any moisture that may be mechanically carried over.—*Jour. Gas Lighting.*

THE CHEMICAL COMPOSITION OF PEARLS.

A PAPER was recently read before the Royal Society by George Harley, M.D., F.R.S., and Harald S. Harley.

(1) As regards oyster pearls: Of these, three varieties were examined—British, Australian, and Ceylonese.

The qualitative analyses showed that they all had an identical composition, and that they consisted solely of water, organic matter, and calcium carbonate. There was a total absence of magnesia and of all the other mineral ingredients of sea water—from which the inorganic part of pearls must of course be obtained. Seeing that ordinary sea water contains close upon ten and a half times more calcium sulphate than calcium carbonate, one might have expected that at least some sulphates would have been found along with the car-

bonates, more especially if they are the mere fortuitous concretions some persons imagine them to be; a view the authors cannot indorse, from the fact that by steeping pearls in a weak aqueous solution of nitric acid, they are able to completely remove from them all their mineral constituents without in any way altering their shape, and but very slightly changing their naked eye appearances, so long as they are permitted to remain in the solution. When taken out, they rapidly dry and shrivel up. Dr. George Harley will take occasion to point out in his next communication, which will be on the microscopic structure of pearls, that a decalcified crystalline pearl bears an intimate resemblance to a decalcified bone, in so far as it possesses a perfectly organized matrix of animal matter. No phosphates whatever were found in any of the three before-named varieties of pearls.

The next point being to ascertain the exact proportions of the substances composing the pearls, and pure white pearls being expensive, from having ascertained that all the three kinds they were operating upon had exactly the same chemical composition, instead of making separate quantitative analyses of them, they simply selected two pearls from each variety, of as nearly the same size and weight—giving a total of 16 grains—and analyzed them collectively, the result obtained being: carbonate of lime 91·72 per cent.; organic matter (animal) 5·94 per cent.; water 2·23 per cent.

(2) Composition of cocoa nut pearls:

A portion of a garden pea sized cocoa nut pearl, weighing 14 grains, was subjected to analysis, and found that, like shell fish pearls, it consisted of carbonate of lime, organic matter (animal), and water.

It had all the external appearances of the pearls found in the large clams (*Tridacna gigas*) of the Southern Ocean, being perfectly globular, with a smooth, glistening, dull white surface, and resembling them exactly in microscopic structure. Besides which, in chemical composition it bore no similarity to cocoa nut milk, to which it is supposed to be related; for cocoa nut milk is said to contain both the phosphate and the malate, but not the carbonate of lime. That there are pearls found in cocoa nuts the authors do not presume to deny; all they mean to say is that they are doubtful if the specimen examined had such an origin.

(3) As regards mammalian pearls:

These so called pearls have been met with in human beings and in oxen.

In so far as naked eye appearances are concerned, a good specimen of the variety of pearl now spoken of is quite undistinguishable from a fine specimen of Oriental oyster pearl, from its not only being globular in shape, and of a pure white color, but from its also possessing the iridescent sheen so characteristic of Oriental oyster pearls of fine quality.

In chemical composition, however, mammalian pearls bear no similarity whatever to pearls found in shell fish, for they are composed of an organic instead of an inorganic material—namely, cholesterin. In microscopic structure again, they bear a marked resemblance to the crystalline variety of shell fish pearls.

ARTIFICIAL PRODUCTION OF PHARMACOLITE.

ANOTHER interesting mineral synthesis has just been effected by M. Dufet. Native di-calcium arsenate, pharmacolite, occurs very sparingly upon the known parts of the surface of our globe, and is so rarely found in well defined crystals that M. Des Cloizeaux has only just completed his investigation of its mineralogical and optical properties. Generally it is found in the form of silky fibers, but is at times met with in perfect monoclinic prisms of pearly luster and frequently possessing a pink tint. M. Dufet has succeeded in producing these beautiful crystals by a very ingenious method. Two concentric vases, the outer containing nitrate of lime and the inner di-sodium arsenate, were filled with water, and so arranged that very slow diffusion occurred between the two liquids. The conditions of nature were evidently very closely imitated, for the very gradual precipitation thus brought about resulted in the formation of groups of crystals, exactly resembling those of pharmacolite. Goniometrical measurements showed that they belonged to the monoclinic system; and the close approximation of the fundamental angles to those of the mineral given by Haidinger and Schrauf, and especially the still more remarkable closeness to the values just arrived at by M. Des Cloizeaux, leave no doubt as to the identity of the artificial with the natural. The chemical analysis of M. Dufet's crystals leads to the formula $HCaAsO_4 + 2H_2O$, and it thus becomes chemically as well as physically isomorphous with brushite, the corresponding phosphate of calcium, $HCaPO_4 + 2H_2O$. This result clears up the discrepancy between the acknowledged formula of the latter mineral and that given by older mineralogists for pharmacolite, $2HCaAsO_4 + 5H_2O$. The number of minerals which have now been reproduced in the laboratory must be very considerable, and every day the likelihood is increasing that those noble species which have for ages been prized as gems may discover the secret of their formation to some indefatigable worker. Rubies and sapphires have already yielded, possibly the diamond may not prove refractory much longer.—*Nature*.

SIR HUMPHRY DAVY, F.R.S.

WE give a portrait of Sir Humphry Davy, who, at the commencement of this century, held the most commanding position of all England's scientific worthies. Humphry Davy was born at Penzance on the 17th of December, 1779. He was educated at the grammar schools of his native town at Truro. At the age of fifteen he became the pupil of Dr. Borlase, of Penzance, with a view of entering the medical profession, and thus was led to begin the study of chemistry. While with Dr. Borlase, Davy made rapid progress, and entered upon a series of original investigations, the results of some of these appearing in a work published by Dr.

SIR HUMPHRY DAVY, F.R.S.

Beddoes, who, noticing the talents of young Davy, obtained for him the appointment of experimental chemist at the Bristol Institution. Here he became acquainted with Davies Gilbus, who was afterward president of the Royal Society. In 1801 Davy came to London, and on the 25th of April in that year delivered his first lecture at the Royal Institution. The subject was galvanism. In the month of May following he was appointed professor at the Institution, and at this period his work consisted largely in investigating electrical subjects. The results of his researches were first given to the world in his Bakerian lectures of 1807-1811, and were published in the *Philosophical Transactions* of those years. We shall not enter into the details of Davy's work. To him we owe the discovery of the decomposition of the fixed alkalies by electrolytic means. In fact, he may be said to be the father of the electrolytic branch of electrical science.

From the year 1809 to 1814 the following papers, of which he was the author, were read before the Royal Society and published in their *Transactions:* "Electro-Chemical Researches and the Decomposition of the Earths, with Observations on the Metals obtained from the Alkaline Earths," and "On the Amalgam procured from Ammonia," read June 30, 1808—the Bakerian lecture for 1809; "On some New Electro-Chemical Researches on Various Objects, particularly Metallic Bodies, from the Alkalines and Earths," and "On some Combinations of Hydrogen," November 16, 1809; "Researches on the Oxymuriatic Acid, its Nature and Combinations," and on the "Elements of Muriatic Acid, with some Experiments on Sulphur and Phosphorus," July 12, 1810—the Bakerian lecture for 1810; "On some of the Combinations of Oxymuriatic Acid Gas and Oxygen," and "On the Chemical Relations of these Properties to Inflammable Bodies," November 15, 1810, and other papers. One of his greatest inventions was that of the miner's lamp, the first paper in relation to which appeared in the volumes of *Transactions* for 1815, and the last in 1817.

Sir Humphry became president of the Royal Society in 1820, and he continued to contribute papers on subjects of great interest for some time. He was knighted on the 8th of April, 1812 (afterward created a baronet), and he died on May 12, 1829, at Geneva. Bold, ardent, and enthusiastic, Davy soared to great heights of science; he commanded a wide horizon, and his keen vision penetrated to its utmost boundaries.—*Electrical Engineer*.

[COUNTRY GENTLEMAN.]

CALEB COPE.

AMERICAN horticulture is again in mourning for one of its great patrons, Caleb Cope, one of the early founders and for many years president of the Pennsylvania Horticultural Society—in those days when this famous society was running a race with the no less famous Massachusetts society for the leadership of horticulture in America. Undoubtedly to these two great societies, with Wilder in one and Cope in the other, is due much of the great progress in the love of gardening which, during the last half century, has been so rapid in the new world.

Caleb Cope belonged to a family eminent among the merchants and famous men of America. Two of them—Cope Brothers—founded the famous line of packet ships between Philadelphia and Liverpool, and Prof. Edward D. Cope is known for his eminent scientific attainments all over the world. Caleb Cope was born in Greensburg, Pa., in 1797, soon after America became independent, and was therefore in his 91st year at the time of his death, on the 12th of May. He became the leading dry goods merchant in Philadelphia, and after amassing considerable wealth, bought an estate called Spring Brook, in the suburbs of the city, solely to gratify his love of gardening. The grounds were beautifully laid out, and extensive ranges of glass established for the growth of fruit and flowers. There were cold graperies, and graperies for early forcing—in the latter maturing fruit as early as March; peach and nectarine houses; houses for forcing strawberries, tomatoes, cucumbers, and other vegetables; camellia house; cactus house; orchid house; and houses for the regular run of mixed blooming plants. When the *Victoria regia* first flowered, and made such a sensation in England, Mr. Cope interested Sir Wm. Hooker, and through his assistance plants were grown, and a magnificent house built for it. Here it flowered and was the center of as much attraction as it received in the old world. Every new plant was purchased as fast as it appeared in the old world or new, and lovers of Flora flocked to see the treasures she had here continually to show them.

The remarkable sympathy with humanity which he possessed was especially shown in his horticultural pursuits. A childless widower, with but a small part of the products of the establishment required for his own use, all went to friends or public institutions, the public hospitals getting the chief portion of the forced fruits and vegetables. Under his presidency the Pennsylvania Horticultural Society was the most popular institution in the city, and a large surplus was made over and above its expenses, and invested as a contingent fund. His own collections of course contributed largely to the interest of the exhibitions. All the public institutions of Philadelphia owed a large measure of success to his active and generous aid and patronage.

Suddenly, about 1855, by the abuse of confidence by a partner, the whole of his wealth was swept away, and the firm went into bankruptcy. The collections of plants went to the auction mart, and the estate was sold to parties with no love for horticulture. The horticultural glories of Spring Brook closed. It is now a public charity, under the will of the great tragedian, Edwin Forrest—the Forrest Home for Unfortunate Actors. Mr. Cope's friends came to his rescue. He again entered business, was successful, paid every dollar of the old indebtedness of his firm, and accumulated enough to buy another beautiful home in the suburbs of Philadelphia, turning his attention, however, to out-door gardening only. With the same generosity that marked his earlier career, these grounds were also free to the public. It was practically a public park, and thousands bless the liberal owner for many a pleasant hour spent on his grounds.

When the Southern States rebelled in 1861, there were large numbers in the South true to the old government, who, soon after losing their wealth, escaped through the lines to the North. Among these were the widow and daughter of one of the leading families of Nashville, who came to Philadelphia. These refugees always excited the sympathy of the Northern Unionists. These two fell to Mr. Cope's charge, and he subsequently married the daughter, who, with two sons, now survives him.

On account of advanced age at the time of their decease, living horticulturists have but a faint idea of the great debt due to Wilder and Cope for their work, but those who study the history of the past will fully understand the noble lesson of their lives.

THOMAS MEEHAN.

EVOLUTION IN THE PLANT KINGDOM.*

By JOHN M. COULTER.

PERHAPS I should apologize for selecting a subject that has anything to do with so hackneyed a theme as evolution; but you will discover that I intend neither to explain nor defend it. In this presence neither should be necessary. The purpose is to give an illustration of evolution from the plant kingdom, chiefly because illustrations of this law are commonly taken from the animal kingdom, and also because the case among plants is even more striking. One who staggers at the evolution of the horse can find among plants such interminable intergrading that fixity of species becomes a dream of the past, when they were arranged like puppets that popped up in their places when called for, always looked just alike, and were perfectly expressionless. Zoologists are fortunate in having as their stock in trade forms of life in which man is specially interested, both as an acquaintance and a kinsman. The public that listens with pricked-up ears and discusses endlessly concerning the evolution of birds, mammals, and man, and thus brings a certain popularity to zoology, cares not a straw for the wonderful structures of gymnosperms and lycopods, although furnishing irresistible arguments in favor of a theory that has revolutionized scientific thought. One sort of compensation has been that botanists have been

* Presidential address before the Indiana Academy of Science, December 28, 1887.—*American Naturalist*.

considered a sort of harmless folk, while zoologists are "infidel," or "progressive," apostles of darkness or of light, according to the standpoint of the speaker.

Botanical work has been no less effective and advanced in these latter days; but it lacks that possibility of spectacular display which would keep it in the mouth of the public. Monkeys and men the public wants to know about, but pteridophytes and phanerogams are decidedly prosy.

It will be found, however, upon a fair examination, that botany and zoology are so mutually dependent and helpful that one cannot advance without the other, and the thoughts of both upon such a great question as evolution are practically the same.

Turning aside, therefore, from the broad and much-traveled highway which leads from the moners to man, we will strike into a by-path, which extends from protococcus to phanerogam, and point out a few of its most salient features. Zoologists should be interested in noting how the same ideas have been worked out into great kingdoms, and all should remark the wonderful unity of purpose pervading the whole domain of life.

I shall make no attempt to outline a great scheme into which every plant, however formed, shall fitly fall. If I were younger or less acquainted with botany, I could do this; for a young botanist usually begins by attempting to remodel all existing schemes of classification, just as a young college graduate can put veteran statesmen to shame. Botanists have no family tree arrangement for plants, and will not attempt the construction of one until they know more about the life histories of the lower groups and more about structure in all the groups. As Dr. Farlow said, in his vice-presidential address before the last meeting of the American Association for the Advancement of Science: "On abstract grounds alone, I presume that few botanists would object to the statement that all plants have developed from simple ancestral forms which were nearly related to some of the lower animals. But when it comes to saying in anything like a definite way that certain existing forms have arisen from other lower existing forms or their immediate allies in some past epoch, and so on, until the lowest form is reached, botanists may well insist that imagination should not be allowed too large a scope in supplying missing links. It is precisely in this point that zoologists have an advantage over botanists. The palæontological record of lower animals is more complete than that of lower plants, so that where the zoologist might reasonably form an hypothesis the botanist must rely more on his imagination, until in the end he finds himself in the possession of a chain composed, to a considerable extent, of missing links. As it is, if we would consider the evolution of plants, not getting much light on the progress of the lower forms from palæontology, we are compelled to trust largely to plants as we now find them, and to ask what are the inferences we are permitted to draw from existing structures and conditions."

Not so very long ago it was thought that at least one fact in classification was impregnable, viz., that there were two great and very distinct groups of plants, called phanerogams and cryptogams. These two were set off against each other as antipodal groups, between which there was nothing in common. Unfortunately, the names given to these groups were simply an expression of the botanical knowledge of the time. "Apparent reproduction" and "hidden reproduction" may have correctly expressed the facts with respect to these two groups once; but they are very far from doing so now. The modern botanist, with his more complete appliances and methods, has begun to resolve the great nebulous mass of cryptogams, and has discovered in it distinct systems and groups. The whole subject of cryptogamic classification is, of necessity, quite inchoate. Certain groups and relationships have been distinctly defined; but among them and around them there float numerous hazy forms that refuse to be classified. Our knowledge is not sufficient to attempt the work with any degree of certainty, but certain broad principles have been struck out which will serve to guide.

It is known now that phanerogams form but one of several correlative groups. The most useful scheme of classification at present makes the number seven. These seven primary groups must be considered merely as convenient pigeon holes in which to distribute our facts.

It is not my purpose to go into the details of any supposed order of evolution of the plant kingdom, but to give some general thoughts concerning it and to trace through the development of a single structure. Generalization is always easier than details; for in it one is never embarrassed by the facts.

It seems probable that the plant kingdom must have begun in some such form as protococcus, the common green slime found staining foundation stones, bark, etc. It surely represents the unit of structure and of function in the vegetable kingdom. We can conceive of no simpler plant form than a single chlorophyl-bearing cell. Some of you will recall the fact that we have unicellular plants without chlorophyl, such as yeast and bacterial forms, as well as forms called plants that seem to be mostly naked protoplasm, such as slime moulds; but the former probably represent degraded forms, while the animal or plant character of the latter remains in doubt. At any rate, they probably have a far greater complexity than was formerly supposed. We have thus come to consider protococcoid forms as our foundation stones in rearing the structure of the plant kingdom. Through all the thallophytes (representing the four lowest of our seven primary groups) there run two parallel lines, the typical or normal plants, containing chlorophyl, and the degraded plants, which are destitute of chlorophyl. This distinction is a very deep-seated one in the plant kingdom, for chlorophyl-bearing plants alone can do normal plant work, viz., the conversion of inorganic to organic material through the agency of chlorophyl and sunlight. Plants without chlorophyl must live as parasites or saphrophytes, a degraded habit which leads to degraded structure. The former in the first four groups are called algæ, the latter fungi. The general opinion, brought out clearly in the address of Dr. Farlow, already referred to, is that fungi are degraded representatives of algæ—relatives in reduced circumstances, whose lazy habits of parasitism have entailed upon them degenerate bodies. Just what fungi have descended from what algæ it is perhaps impossible to say. The chances are that some of our important fungi are degraded representatives of algal forms which no longer exist. Specific statement with regard to this relationship is little better than guessing; but the general proposition seems to be fairly well established. We have advanced, then, thus far: that of the two parallel lines, algæ and fungi, which run through the four lowest plant groups, the plant kingdom is to be considered as having advanced in the line of the algæ, the chlorophyl-bearing line; while the fungi are simply so many degraded forms, which lie strewn along this line of general progress, like drift wood stranded along the banks of a stream. For our purpose, then, the fungi are to be dismissed, their probable origin having been sufficiently indicated. Starting, then, with protococcoid forms, advancing along the lines of algæ, and into the chlorophyl-bearing members of the groups above, what notions of evolution can be obtained? Examining our present schemes of classification, it will be discovered that chief stress is laid upon the methods of sexual reproduction. It is, as yet, the best thread upon which our facts can be strung, and it usually expresses so thoroughly the highest effort on the part of the plant, that as it advances from simplicity to extreme complexity it seems but fair to consider it a good index of relative rank. I intend to give in merest outline the development of sexual reproduction, guarding such an attempt with the following statements:

1. This is taken as but a single striking line of development, and must be understood to be accompanied by many other details in asexual reproduction and vegetative structure which bear it out, but which we have no occasion to mention—just as in describing the evolution of the horse the toes are seized upon as the one among other structures most striking and most simple of presentation.

2. There are hosts of side issues which represent departures greater or less from this general line of advance, and which cannot be taken into account in this general sketch. In general, they can be all explained by the law of adaptation.

3. Even the line I propose to follow can be but imperfectly presented; as there is not knowledge sufficient to make it as complete as we would like it, and not time enough to present it as complete as we know it.

Taking, therefore, this thread of sexual reproduction as a guide through the labyrinth of plant forms, we may come to some glimmer of light.

Naturally, the lowest group would contain those plants in which no sexual reproduction has been discovered. In recognition of this position, as well as their probable position in point of time, they have been called protophytes, or "first plants." The lowly character of lacking sexual reproduction is further borne out in their structure, for they are mostly one-celled forms. In this group stands protococcus as a type, a single-celled chlorophyl-bearing plant with no discovered sexual reproduction; and, as degenerate representatives, the bacteria and yeasts. You will notice, however, that the definition of this group, on the basis we have adopted, is a negative one, being not as much what we have found, as what we have not found. It follows that this group furnishes a kind of limbo to which all one-celled plants are consigned, in case no sexual reproduction is found, a sort of unresolved nebulous mass, in fact, a cloak for ignorance. It is like the man who undertook a great scheme of classification, and made his two principal divisions "things that I know" and "things that I don't know." The first group he could classify reasonably well; the second he did not have to classify. In this lowest chamber of protophytes, every now and then the garment of sexual reproduction is discovered, and its wearer invited to take a place in some upper chamber. But the chances are that the chamber will never be completely emptied, and that there will always be some plants called protophytes.

In the second group we would expect to find the beginning of sex reproduction in its simplest form; and to understand what the simplest form would be, the nature of sex reproduction must be defined. It consists in the mingling of the contents of two cells to form a new one. This new cell is the progeny, and develops more or less directly into the structure of the parents.

Applying this definition to some one-celled form as protococcus, the simplest possible method of sex reproduction would be for two cells to come in contact and mutually discharge their contents into a blended mass, which becomes a new cell and presently resembles the parents. Such is the beginning of sex reproduction as we find it in the second group of plants; but it will be noticed that there is no distinction of sex. Both cells are constructed alike and act alike; neither is receptive, for the new cell is constructed upon neutral ground. Sexuality has been attained, but not bisexuality. For this reason, the second plant group is frequently called the "unisexual group;" or, from the fact that the cells are for a time yoked together, they are technically called zygophytes, or "yoked plants." In this group, not only is sexuality begun, but bisexuality is hinted at. Plant bodies now begin to consist, not of single cells, but of cell groups, usually arranged in a chain, forming filiform or thread-like plant bodies. In these filaments or chains of cells, any cell (for they are all alike) can become a reproductive cell and join issues with any other cell, either in the same filament or in another. There is no setting apart of special cells to do this special work, for it is done equally well by all, and all are ordinary vegetative cells. The first hint at bisexuality comes with the fact that one of these conjugating cells becomes receptive, receiving the contents of the other, and within it the spore or progeny cell is formed.

Such is the case in the common spirogyras, or "frog spittles." Although one cell becomes receptive, there is no difference in form nor in contents, and it seems immaterial which becomes the receptive one. In other forms, the development of the spore within the receptive cell demands more or less change of form, thus making a cell differing in appearance from the ordinary ones. To sum up the general phases of this advance in the second group, or zygophytes: sexuality is attained, at first with no distinction of sex; then one cell becomes receptive, but differs in no respect from any other in form or contents; and finally, the receptive cell becomes more or less changed in form by the development of the spore.

In the third group we would expect to find bisexuality distinctly worked out, but of the simplest kind. The simplest kind of distinct bisexuality would consist in setting apart two cells for the special performance of this function, differing from the ordinary cells of the plant body and from each other in form and contents. Naturally, the receptive or female cell, in which the spore is to develop, would be the larger, probably the largest cell produced by the plant. Such is the average condition of sexuality in the third group, called oophytes, or "egg spore plants," in reference to their large spores. It is to be noticed that these male and female cells differ in form and function only from the ordinary cells of the plant body; they are not favored and cared for by any sort of protection. At this point we are confronted by a phase that needs explanation. The life history of every plant may be considered a cycle, from the spore which produced it round to the spore which it produces. The cycle is traveled continuously without cessation, except at some one point, which is known as the "resting stage." Every plant, in the life cycle referred to, must, at some point, pass through a resting stage, in which condition the plant activities lie dormant, as if to gather strength for the rest of the journey. This stage must always be a protected one, protection which not only shuts out adverse external conditions at a time of low vitality, but prevents response to favorable ones until after a certain lapse of time. In the groups already considered, this resting stage occurs at the spore phase. The protection provided is simply a thick, heavy wall about the spore itself; and in this condition the plant exists for a time and then runs its cycle, round through parent form to spore again. To pass through the resting stage at the spore phase is characteristic of a low type. In the third group the resting stage is pushed gradually forward, until the sex spore becomes, not a rather permanent phase, but simply one of the transient phases, the resting stage occurring after the spore has developed subsequent structures.

The next phase in the sex reproduction, the one naturally expected in the fourth group, is the protection of the male and female cells or organs. Set apart heretofore in form and function, they are not protected; but in the fourth group this is gradually and at length very completely provided for, as indicated by the group name, carpophytes, or "plants with spore cases." In certain members of the group—those which look toward oophytes—the male and female cells are at first as naked as in oophytes, and if the spore passed into the resting stage the plants would belong to that group; but the spore, as soon as formed, proceeds to develop other structures, and, along with the female cell in which it is contained, develops a complex structure called a spore case, and this is the resting stage.

Summing up the advance made in the fourth group, we find male and female cells distinct in form; the latter finally protected; and the sex spore ceasing to be the resting stage, and becoming an evanescent phase which passes directly into a complicated structure, which itself is the resting stage. Subsequently, from this complicated structure, or "spore case," forms like the parent plant are produced by means of so-called spores, not formed by sex union, but by ordinary cell division, and for that reason called asexual spores. They are simply reproductive bodies cut off from the parent stock, and are chiefly for the dissemination of the plant, no more a product of the sex act than the buds used in grafting or the "slips" in transplanting; but they are the "spores" commonly spoken of among cryptogams, and their name is legion. The essential difference between sexual and asexual spores cannot be too strongly pointed out, for they have led to endless confusion of ideas. Note now the relation of things in this fourth group. The sex spore produces the structure called the spore case, which in turn produces asexual spores by ordinary cell division, which in turn reproduces the original parent. In this group, therefore, in the effort to protect the progeny the resting stage was pushed forward, and that condition of things known as "alternation of generations" originated. As a result, we have in a single life cycle two plant phases, each producing spores, but in a very different way. One phase bears the sex organs and produces the sex spore, and hence is called "the sex plant;" the other is produced by the sex spore, bears no sex organs, produces asexual spores, and hence is called "the asexual plant." The asexual spores produce the sex plant again, and so the cycle is completed. The idea of protecting the sex organs or their progeny, begun in the fourth group, becomes more and more fully developed in the groups above. After the covering to the female cell is established, there remains a neck-like passageway. This passageway becomes more elongated, and more or less guarded, until in the highest group it too is completely blocked up by loose cellular tissue, which must be penetrated by what is called the "pollen tube."

To summarize at this point: we have an asexual group as the lowest; then a unisexual group; then a bisexual one; bisexuality appearing as the goal in the first three groups. In the fourth appears the idea of protection, which gradually becomes more and more perfected in method, until, without any sensible break in the series, we reach completest protection in the seventh group, or phanerogams. Also in the fourth group, after bisexuality had been attained, we find alternate generation, and it is in the development of that character that we find the most striking line of advance from the fourth group to the seventh. Keep in mind that the same road is also completely graded and bridged by way of "protection," as has been already referred too. Given, then, as our starting point (1) a sex plant which carries sex organs and produces a sex spore, and (2) a resulting asexual plant which produces asexual spores, and remembering that the two are but arcs of the same circle and alternately produce each other, what is the next complication that indicates advance?

The next step, besides the completer protection already referred to, is the completer setting apart of the two phases, so as to make them in structure what they are in function, distinct plants. In members of the fifth group, mosses for instance, we find this to be the case. The ordinary moss plant, which bears the sex organs, is, of course, the sex phase; and borne upon it, though as organically distinct as if it grew upon any other mechanical support, we find the structure which develops from the sex spore, the so-called "fruit," or spore case. This is the asexual phase, and produces within itself asexual spores (the only spores meant in the ordinary description of mosses). These spores, in turn, produce the sex phase, or ordinary

moss plant, and the cycle is complete. There is here a distinct setting apart in function, and, as usually follows, in form also. To the one phase is assigned sex reproduction; to the other the dissemination of the plant by asexual spores. The ordinary vegetative structures, representing root, stem, and leaves in the higher groups, are here included in the sex phase also; so this phase is the prominent one, the one ordinarily observed and spoken of as "the plant;" while the asexual phase is more inconspicuous, and, being mechanically borne on the other, seems to be but a part of it.

From this point on, the tendency is to confine the sex phase more and more entirely to the business of sex reproduction, and to transfer the vegetative structures more and more completely to the asexual phase. The result is, that as we advance toward the higher groups the sex phase becomes less and less prominent, as the function is taken away from it which involves size and display; while the asexual phase, taking on the function involving display, becomes more and more prominent, and is popularly styled "the plant." So that, while "the plant" in the case of mosses is the sexual phase in the life cycle, "the plant" in higher groups is very probably the asexual phase, representing the so-called "fruit" of the moss. As the sex phase is to be more and more confined to sex reproduction, it can easily be understood how it can be reduced more and more, until it has only the cells actually needed; and these cells may be reduced to two, one to represent the plant, and the other the sex organ growing upon it. This seems to represent the goal set before the sex phase, when in the sixth group the vegetative structures begin to leave it. From this point on evolution reduces and simplifies the sex phase, increases and makes more and more complex the asexual phase. The sex phase thus begins simply in the lowest groups and ends simply in the highest, reaching in the fifth probably its greatest complexity. While this is true of the structure of the sex phase, it is not true of the sex function, for the very highest possible degree of differentiation in this regard is attained in the highest group.

In the sixth group, represented by ferns and their allies, we find a very wide distinction between the sexual and asexual phases; the latter having become very prominent and having possessed itself of most of the vegetative structures, being the ordinary fern plant with its great display of vegetative structures and asexual spores, but no sex organs. Linnæus may well have examined the fern in vain for any evidence of sex organs, for he only knew of this prominent asexual phase, and in his despair consigned the group to "cryptogams," "hidden sexuality." The sexual spores (borne, you may remember, upon the leaf structures of the fern) develop, of course, into the sex phase; but that is so small and hidden among the mould in which the spore has fallen, that it may well escape observation. It is simply a minute flat, disk-like body, with vegetative cells and root like process enough to make it able to live long enough to accomplish its function of sex reproduction. But it bears the sex organs, produces the sex spore, and from it there arises the beautiful or stately asexual plant. The reduction of the sex phase could go no further than this, and at the same time compel it to make its own living from soil and air. If any more reduction be made, the sex phase cannot be organically separated from the other, but must depend upon it for elaborated food.

By this means the utmost possible reduction could be reached, and we must expect this to be the next step in advance. For instance, the asexual spores of the fern are scattered over the soil. From them springs the reduced sex phase, known as the prothallium, and capable of independent existence. Any further reduction, which would make it incapable of independent existence, would necessitate that the asexual spore be not separated from the asexual plant, but developed into the prothallium upon it so as to receive elaborated nourishment. The reason why a prothallium cannot be indefinitely reduced and still retain the power of independent existence is not far to seek. It is on the same principle that a small battery cannot work an indefinite amount of wire. The formation of high grade reproductive cells is an exhaustive work, and it would require more than a few cells to manufacture such an amount of highly organized substance from crude material. Hence we reach a point beyond which it would be a physical impossibility to reduce the prothallium, without arranging to supply it with material already highly organized.

Remembering, then, that from the sixth group, represented by ferns, higher rank is to be marked by a reduction of the sex phase or prothallium, which finally cannot be separated from the asexual plant, let us note a new phase of differentiation which begins to be prominent in the upper members of the sixth group, and continues as the highest expression of differentiation in the seventh and last. Although vegetative organs have departed from the sex phase, there still remains a double function, namely, the production of male and female cells or organs. It seems to be a law, that so long as anything remains to be differentiated, differentiation will continue; and the separation of the sex organs is its next possible expression. Instead, therefore, of having a single prothallium bearing both male and female organs, we find two prothallia—one male and the other female. This state of things is reached by one set of organs first becoming functionless, and finally being suppressed. Remembering that these prothallia are developed from asexual spores, it does not seem strange that this dimcism extends presently to these spores themselves, and that we soon find what may be styled (from the nature of their product) male and female asexual spores. This brings us to the heterosporous arrangement, a feature which continues to the last, and which must be considered a high rank character, possessed only by the higher members of the sixth group, and by the seventh; and yet, through the very midst of this condition of things, accompanied as it is by many intergrading characters in all the other plant structures, the old abyss between cryptogams and phanerogams was supposed to run. To sum up the lines of advance, with which we enter the group phanerogams, we find male and female spores, producing male and female prothallia, and those prothallia so much reduced that not only do they not become separated from the asexual plant, but are developed within the asexual spore itself. But these same important characters are to be found among the highest cryptogams, and we must conclude that any line of separation is one of our own drawing, and has no representation in nature.

It remains to apply to the well known parts of any flowering plant the terminology that we have been using in outlining the evolution of the sex apparatus. The asexual phase, or part of the cycle, is "the plant," with its rich display of vegetative organs, consisting of root, stem, leaves, and their various modifications. This asexual phase produces asexual spores of two kinds, called male and female, because they are to produce male and female prothallia. It would be an interesting line of development to note the gradual differentiation of the apparatus for making these asexual spores, but that is aside from our purpose. The final result is, that in the flowering plant we are considering, highly specialized sets of organs produce the two kinds of asexual spores, which have been called pollen grains and embryo sacs. It seems strange to be forced to give up pollen grains or embryo sacs as sexual affairs, for in our old notion of things they represented the very essence of sex; but the fact remains that they are asexual spores and simply give rise to prothallia which bear the sex organs and give rise to the sex spore.

The two prothallia which are developed from these asexual spores have reached the highest degree of reduction, developing within the spores themselves. In the case of the pollen spore two or more cells are developed, which may be easily seen by the use of the proper reagents, and this small group represents the male prothallium, one of the sex phases in the life cycle. This much reduced plant sets apart one or more of its cells to do vegetative or growth work, and another to be the male organ. A very vigorous growth of this prothallium is demanded in the development of the pollen tube, through which the male cell discharges its contents. This pollen tube does not usually find an open passageway, but one that is blocked up with spongy tissue, called "conductive tissue," through which it makes way like a parasite invading the tissues of a host plant.

In the case of the embryo sac, the female asexual spore, the development of the prothallium is still feebler, the cells representing it not only being few in number, but free from each other—a sort of disorganized tissue. The cells representing the female organs are clustered near the apex of the embryo sac, forming what we now call the "egg apparatus," while those that probably represent the vegetative cells of the prothallium are clustered at the other end of the embryo sac, and are styled "antipodal cells." In pines, representing the lowest group of flowering plants, the female prothallium is a very distinct and compact tissue, bearing regulation female organs, the so-called "corpuscula." This but shows their position upon the lower border line of phanerogams. The sex phase in the life cycle, therefore, which in mosses stood for the whole plant as we ordinarily recognize it, in phanerogams has become reduced to little clusters of cells developed within the pollen spore and embryo sac, so inconspicuous that it has remained for the modern reagents to discover their existence. The real sex spore, or oospore of phanerogams, is the single fertilized cell in the embryo sac, which at once develops into the embryo, at which point phanerogams pass into the resting stage, in this group called "the seed." The sex spore, since the fourth group, has become such an evanescent thing, so out of reach of common observation, that very naturally it has been the common opinion that the comparatively permanent asexual spores are sex affairs. Sex spores are directly formed by sex union; while pollen grains and embryo sacs are never formed in any such way. Thus have I hastily traced one of the principal threads upon which our botanical facts are strung. And as one examines the subject in more of its details, he becomes irresistibly impressed with the idea that here is a great scheme of development, directed by laws of which we are beginning to catch glimpses, and by which the whole fabric of a great kingdom has been beautifully and continuously worked out.

FLOWERING TREES AND SHRUBS.

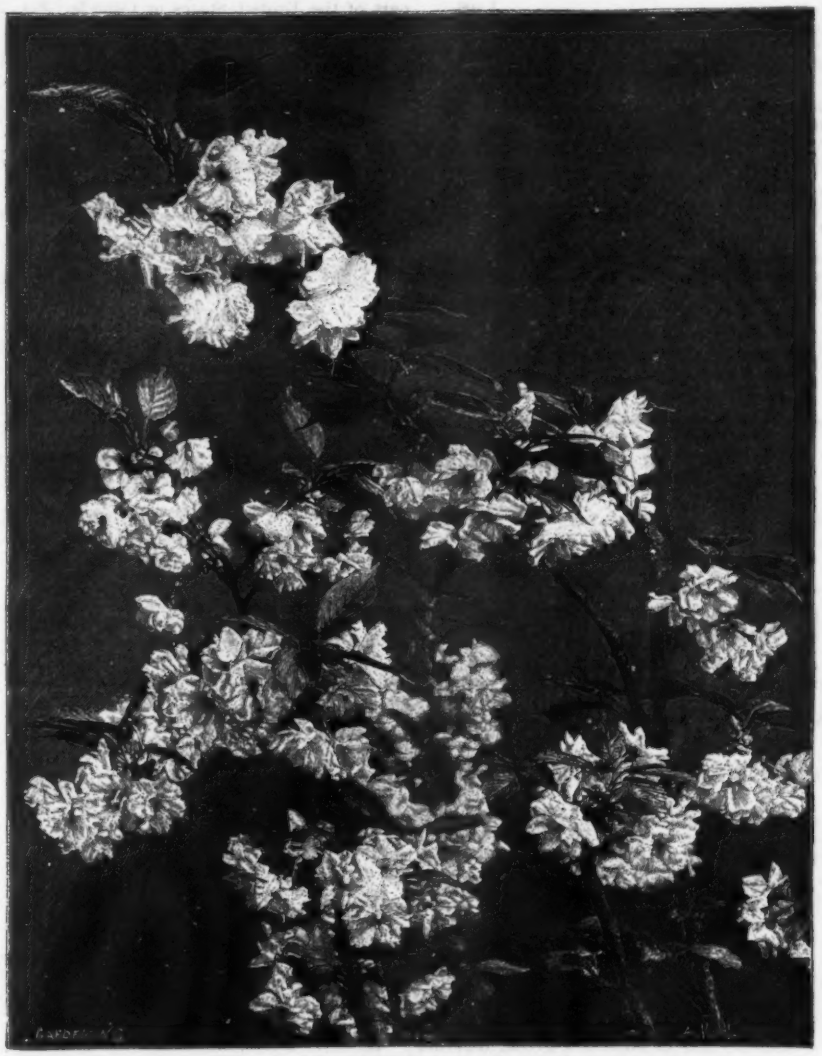
By W. GOLDRING.

Cerasus (Cherry).—Our lawns and shrubberies owe so much of their early summer beauty to the cherries that they must be ranked among the finest ornamental flowering trees we have. There is hardly a species in the genus that is not beautiful, but as they are so numerous that only large gardens could represent them all, a selection of the finest must be made. The double-flowered cherries are undoubtedly the most beautiful and best suited for lawns and shrubberies, as they endure longer in flower than the single forms. The finest double-flowered cherry is C. serrulata (see illustration), a Chinese species which may be recognized at a glance by its peculiar growth, the long rigid branches being invariably spreading in an ascending, not erect direction, and with rarely a central leader. The flowers are very double, like rosettes, white, suffused with a delicate pink, and produced in clusters completely wreathing the branches. C. Sieboldi is synonymous with this species; and very similar to it, if not identical with it, is that known as Waterer's double-flowered cherry. C. Juliana is another very beautiful double-flowered cherry, having large rosette-like blossoms of a delicate blush pink. It is known as St. Julian's cherry. The double forms of the common cherry, C. Caproniana and C. Avium, are extremely fine, and are both known under the name multiplex. In both varieties the flowers are very double and pure white. The earliest to bloom is C. Avium multiplex, and this is quickly followed by C. Caproniana multiplex, which is known also as ranunculiflora. The names of the various double cherries are so much confused in nurseries, that one can never be sure of obtaining the correct sort by asking for it under a particular name. The best way is to choose the kinds when in flower. Among other catalogue names for double-flowered cherries are C. Lannesiana, serotina fl.-pl., hortensis fl.-pl., carneaplena, pseudo-Cerasus fl.-pl., but these either represent those kinds described or slight varieties of them.

The single-flowered cherries are not so numerous in

THE DOUBLE WHITE CHINESE CHERRY (CERASUS SERRULATA).

nurseries, as the demand for them is not great. An indispensable tree, because of its graceful habit of growth, is C. Mahaleb, and the profusion of its white flower clusters in May make it highly attractive. The weeping variety of it (pendula) is one of the most elegant of all deciduous trees, and is preferable to the original. The All Saints' cherry is likewise a graceful lawn tree, and interesting because it flowers all the season from spring till autumn, and carries blossom



WATERER'S DOUBLE-FLOWERED CHERRY (CERASUS WATERERI).

and ripe fruit at the same time. In some years it flowers again in autumn. The dwarf-growing C. Chamæcerasus and C. depressa are useful for planting on the margins of shrub groups or associating with bold rocks, as their natural growth is graceful. The Bird cherries, of which our native C. Padus is the type, are valuable ornamental trees of large growth. In localities where the Bird cherry does not grow naturally, it is quite handsome enough for planting as a lawn tree, or in shrubberies and plantations of exotic trees. Still finer are the North American Bird cherries, C. virginiana and C. serotina, both large deciduous trees, of regular form and with dense heads. Their flowers are in long clusters, like those of our native Bird cherry, but are produced later and last longer, especially those of C. serotina, which is the finest of the two kinds and preferable in every way, being hardier and more vigorous. Too much cannot be said in favor of C. serotina as a lawn or plantation tree, and its value is now recognized by some of our nurserymen, who are getting large stocks of it. The common evergreen laurel (C. Laurocerasus) and the Portugal laurel (C. lusitanica) cannot be strictly called flowering shrubs, though when in flower and fruit they are beautiful. All the deciduous cherries thrive well on poor soils and grow to perfection in sandy districts, and this fact adds much to their value.

Cercis (Judas Tree).—Of the three different kinds of Judas tree in gardens, the commonest and the most beautiful is that from South Europe, and which for nearly 300 years has been a favorite tree in English gardens. This is C. siliquastrum, a tree of humble stature which makes when old a picturesque flat-spreading head, usually rising about 15 feet in height. In spring, generally about the middle of May, it is adorned with a profusion of deep pink blossoms, which garland every leafless branch and twig, and make the tree a singularly beautiful object, even among the many bright-flowered hardy trees and shrubs that bloom at the same time. In some years it flowers again in autumn. After the flowers come the leaves, which are kidney-shaped and of a peculiar pale green that renders the tree in summer distinct from all others. It may be called a perfectly hardy tree in all but the north and cold parts of England, and in places where it does not thrive as a standard it makes a beautiful wall tree. In the northern counties and in Scotland it is commonly seen covering the walls of houses. It succeeds in most soils, but prefers a light, deep loam, and is particularly partial to a sheltered spot protected from cold winds. There are several varieties, differing chiefly in the color of the flowers. There is a white (alba), a very deep pink (carnea), besides a form with variegated leaves (variegata), but this is not to be recommended. It is a tree of slow growth, and though young specimens flower profusely, it is in only very old trees that the picturesque growth of the tree can be seen.

Chionanthus (Fringe Tree).—A very elegant and beautiful small tree, brought to England from North America a century ago. In early summer it bears a profusion of long flower clusters, and as the blossoms are snow white and the petals long and narrow, like a fringe, they have a charming appearance. It likes and must have a moist, but not a perpetually wet, soil in order to succeed well, and prefers a sheltered nook to exposure. It is truly a neglected shrub, though easily obtainable from tree nurseries. A newer species is the Chinese, named C. retusus, which, though its flowers are white and fringy, is scarcely so ornamental, while its perfect hardiness and adaptability for English gardens are not so established as in the case of the Virginian species. The latter is increased by grafting and budding on its relative, the ash, by layers and by seed imported from America.

Clerodendron.—There are but two species in this beautiful genus, for the main part tropical, that have any pretensions to hardiness in this country, but both are worth growing, being handsome shrubs, differing from all others and flowering at a season when others are out of bloom. They are C. fœtidum, a native of China, and C. trichotomum, a Japanese plant. The first is an old garden plant usually seen in greenhouses, but hardy enough for open-air culture in all southern and warm parts. It grows about a yard high, and its strong, erect shoots have large heart-shaped leaves and are terminated by broad and dense clusters of deep rosy pink flowers, produced about August. In southern coast gardens, especially near the sea, this handsome shrub grows quite five feet high, and is extremely handsome for the several weeks it is in bloom. The other species, C. trichotomum, is less common; in fact, it can at present be seen only in botanical collections. It is a free-growing shrub, rising six feet high or more, with large ovate-shaped leaves, and bears large, loose clusters of flowers, the corollas of which are white, the calices being a deep brownish red. It blooms in September; therefore makes a conspicuous object in an otherwise flowerless shrubbery.—*The Garden.*

DISTRIBUTION OF THE NORTH AMERICAN INDIANS.

THE United States Geological Survey has nearly ready for publication a map showing the distribution of the Indian tribes on the North American continent north of Mexico. Including the labor which Major Powell himself and his immediate assistants have expended in the collection, arrangement, and digestion of the material for this map, and that done by the Bureau of Ethnology, it will represent the work of about fifteen years, and will, according to *Science*, from which we obtain this information, be one of the most important and interesting publications ever made by the Geological Survey. All of the Indians living in North America at the time of the white occupation have been divided into linguistic families, and the territory occupied by each one of these families is represented on the map by a distinctive color. The number of these families is about 60, and the number of separate tribes between 300 and 350.

One of the first and most important facts shown by this map is that the territory occupied by each linguistic family, with few exceptions, is continuous. An important deduction in relation to the habits of the Indians is drawn from this fact—that, instead of being nomadic and wandering over the continent at will, as has been generally supposed, the Indians had fixed homes, the boundaries of which were almost as plainly marked as the dividing lines between the several States are to-day, and that their wanderings were within limited areas, rarely or never extending beyond these fixed boundaries. The Indians had their permanent villages, in which they lived for ten, twenty, or, perhaps, fifty years. At certain seasons of the year they went to the coast or to the rivers to fish, or to the forest or plains to hunt. The boundaries of the territories occupied by each family were occasionally changed by conquest. A stronger tribe or family would, by war, push back its weaker neighbors, and thus extend its dominion; but the territory so conquered was recognized by the vanquished, as well as by the victor, as the property of the latter. If the Indians had been nomadic and wandered over the continent or over large portions of it, branches of the same linguistic family would have been found scattered broadcast all over the country.

FOLIAGE OF THE JUDAS TREE (CERCIS SILIQUASTRUM.)

FLOWERING AND FRUITING BRANCHES OF THE JUDAS TREE (CERCIS SILIQUASTRUM).

...ons to this general rule of ...ly interesting, and throw a ... and even forgotten history ...or instance, a little colony of ...a found in Virginia. How it ...ed the mountains, and main... ...t of another family, speaking ...guage, suggests a very interest... ...of the ethnologist. Again, all ...of the continent was occupied ...family, very peaceable Indians. ...Navajos of New Mexico and Ari... ...same family, and are among the ...continent. To their surroundings ...of wresting their new home from ...ants and holding it, as well as to the ...racter of the country, may not their ...acter be attributed? Another little ...thabascans is found in California. ...most degraded families of Indians of ...ica is the Shoshonean, from which the ...ie. And yet, strange as it may appear, the ...ore advanced toward civilization than any ...the Pueblo Indians, are Shoshonean.

...ceedingly interesting feature of the map is ...at number of little families that lived in Cali... ...and Oregon. Some of these comprise only a few ...duals—not more than 40 or 50—and yet their lan... ...s are entirely distinct from those spoken by the ...unding tribes. In one instance, Mr. Henshaw, ...has charge of the construction of the map, found ...California a single man, the sole survivor of his ...e. From him enough was learned to preserve the ...nguage once spoken by his ancestors, but with his ...eath that tongue becomes extinct.

A very curious fact in relation to the distribution of the Esquimaux is that they inhabit the coast of the Arctic regions to the exclusion of other Indians, beginning on the east shore of Greenland and following the coast line of that island around to the point furthest north inhabited by man. Then, beginning on the coast on the mainland, they occupy narrow strips on the north shores of Hudson Bay and along the northern coast of the continent to Prince William's Sound. Throughout all this immense coast line the differentiation of language is very small, so that an Esquimaux from Greenland transported to Behring Strait would, in a month, be able to speak the language of the natives there as well as though he had been born there. In striking contrast were the numerous distinct families of Indians in the valleys of California and Oregon, whose languages are so different that they could not understand each other.

This map, when published, will be accompanied by a report and discussion of the facts it discloses, and will be a very important contribution to the science of ethnology.

PHOTOGRAPHY OF THE HUMAN EYE.

By ELMER BARR, M.D., Buffalo, N. Y.

UP to the present time, so far as I am able to learn, attempts to photograph the interior of the living human eye have not yielded very encouraging results. In the *Philadelphia Photographer* of June 5, 1886, Drs. Jackman and Webster, of Coggestall, Essex, England, give the results of their experiments. They succeeded in showing the end of the optic nerve and an indistinct outline of a part of one or two large vessels.

The chief difficulty in obtaining a photograph of the interior of the eye lies in the fact that the light reflected from the fundus consists almost entirely of red light; and it is well known that ordinary photographic plates are but slightly sensitive to red.

It occurred to me that it would be an improvement to use ortho-chromatic dry plates. With this idea I began experimenting to obtain a photograph of the interior of the living human eye, and the results are better than any others I have seen, showing the optic nerve and vessels quite well.

An ortho-chromatic dry plate is one which by a special treatment is rendered sensitive to green, yellow, and red; the aim in artistic photography being to show the true gradation of tone in a photograph of an object reflecting these colors.

I first tried commercial ortho-chromatic plates, and although more sensitive to green and yellow, such a long exposure was necessary for them to be affected by red that it was impracticable to use them.

I then began experimenting with various formulæ to obtain a plate more sensitive to red, and although the results are much better than those obtained with the commercial plates, they still fail to show the proper gradation of different depths of red, so that the large dark red vessels are not shown with their true distinctness.

The apparatus I have used is rather crude—being merely a modification of Carter's demonstrating ophthalmoscope—and doubtless better results might be obtained with specially constructed apparatus.

For a source of light an Argand gas burner is placed on one side and about eight inches from the concave reflector; an alum cell is placed before the light to intercept the heat rays. The reflector is of 7 inch focus,* and has a central opening of an inch in diameter; it is placed about 24 inches from the eye to be photographed.

About two inches in front of the eye to be operated upon is placed a lens to increase the illumination and to form an aerial image from the rays of light reflected from the interior of the eye. After many trials I decided to use a lens of 2 inch focus, as that gives good illumination and shows more of the fundus than would a lens of longer focus.

Behind the opening in the reflector is placed the camera. The arrangement I use consists of a metal tube carrying a lens, and arranged to slide within another tube having a plate holder at its end; the image is focused by sliding back and forth the tube with the lens.

The lens in the camera has a focus of only three inches, and this I think is important, for it makes a very bright image, and consequently a short exposure—six to ten seconds—is sufficient. The image formed is so small that enlargement is necessary when printing from the negative, but in this process time is not so important an element as when making the exposure, for few persons can hold the eye many seconds without movement.

The plates employed are extra rapid dry plates. They are rendered ortho-chromatic by bathing for one minute in a solution of erythrosin, washed well under the tap, and allowed to dry. They must not be used until dry, but as soon after drying as possible, as they keep but a short time.

The erythrosin bath I make as follows:

Erythrosin	1
Distilled water	1,500
Solution silver chloride in ammonia (gr. xxv-℥j)	½
Stronger ammonia	1

Mix.

In developing I use the pyro and ammonia developer, and pour on the bromide and ammonia first, to prevent fogging. Ferrous oxalate developer may be used if the plates are first soaked 20 seconds in

Potassium bromide	gr. lx
Ammonia	ʒ ij
Water	ʒ vj

Development is commenced in the dark, but after it is well started, a red light may be used in which to finish the operation.

The image is so small that details cannot be seen by a weak light, so that the operator must judge by the general appearance of the image and by the length of time of development—five to ten minutes—as to when the process is complete.—*Amer. Jour. of Ophthalmology.*

* A reflector of longer focus would be better, as a condenser could then be used in front of the light, thus increasing the illumination.

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture**, richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

MUNN & CO., Publishers,
361 Broadway, New York.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ARBORICULTURE.—Flowering Trees and Shrubs.—By W. GOLDRING.—The Cytus, Cercis, and other flowering shrubs.—Their availability and general qualities.—4 illustrations

II. ARCHITECTURE.—Elements of Architectural Design.—By H. H. STATHAM.—Conclusion of this treatise, touching on the general arrangement of buildings.—13 illustrations

III. BIOGRAPHY.—Caleb Cope.—Obituary notice of the president of the Pennsylvania Horticultural Society

Sir Humphry Davy.—The works of the great scientist, with biographical note and portrait.—1 illustration.

IV. BOTANY.—Evolution in the Plant Kingdom.—By JOHN M. COULTER.—A plea for evolution drawn from the vegetable kingdom

V. CHEMISTRY.—A New Apparatus for the Determination of Sulphur Compounds in Illuminating Gas.—Drehschmidt's apparatus and process described and illustrated.—1 illustration

The Chemical Composition of Pearls.—Analyses of molluscan pearls and comparison with so-called mammalian pearls

VI. CIVIL ENGINEERING.—The New Port of Havre.—Detailed account, with illustrations, of improvements in the French seaport.—2 illustrations

The Tay Viaduct.—The principal dimensions and general data of this structure.—Its construction and difficulties in its building.

VII. ELECTRICITY.—New Automatic Fire Alarm.—Apparatus for sounding an electric bell on an increase of temperature.—2 illustrations

Saunders' Lightning Guard.—A very effective protector, one which proved efficient when others failed.

VIII. ETHNOLOGY.—Distribution of the North American Indians.—Recent work of the U. S. Geological Survey, including a systematic study of the subject

IX. MECHANICAL ENGINEERING.—The Chalk Age of Mechanical Engineering.—By J. F. HOLLOWAY, of New York.—A vivid picture of the engineering practices of days gone by, and lives of the old-time apprentices, and the contrast between former and modern engineering

X. METALLURGY.—Notes on American Foundry Iron.—An English review of the qualities of different American pig irons

XI. MINERALOGY.—Artificial Production of Pharmacolite.—A new mineral synthesis lately accomplished by M. DUFET

Asbestos.—By FRANK ALFRED ROGERS.—A review of the history, occurrence, and properties of this curious mineral

Origin of the Names of Minerals.—Some curious instances of mineralogical etymology

XII. MISCELLANEOUS.—A Cotton Centenary.—The approaching centenary of the first successful crop of Sea Island cotton

The International Glasgow Exhibition.—A graphic account of the exhibition in the Scotch metropolis.—1 illustration

XIII. NAVAL ENGINEERING.—The New Cable Steamship Amber.—A new vessel for laying and repairing ocean cables, embodying the last improvements in this class of ships.—1 illustration

XIV. PHOTOGRAPHY.—Composite Portraiture.—Some highly ingenious suggestions regarding the improvement in this class of work

Photography of the Human Eye.—By ELMER BARR, M.D.—A contribution to the photographic study of physiology; details of plates and developers.

XV. PHYSICS.—Class Experiments.—Description of some experiments in natural philosophy from the University of Glasgow.—3 illustrations

Instruments for Recording and Reproducing Speech.—An interesting paper by ALEXANDER GRAHAM BELL recently read before the Fortnightly Club, describing the last advances in this line of work

XVI. TECHNOLOGY.—Cement from Waste Product Lime.—By J. S. RIGBY.—A very valuable and suggestive paper, aiming at the utilization of waste lime from chemical processes

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.

ement.

ear.

bers in any
dollars a

T, from the
ad. Price,

T can like-
ed yearly,
7, or $3.00

TIC AMERI-
E SUPPLE-

agents, and

k, N. Y.

PAGE
W. GOLD-
s.—Their 1000
e.—By H.
the gene-
sident of
with blo-
M. COUL-
gdom.... 1000
n of Sal-
apparatus
nolluscan
tailed ac-
a seaport.
eral data
building.. 1007
aratus for
.—2 illus-
ctor, one
ndians.—
a system-
echanical
ivid pic-
es of the
nd mod-
n English
.—A new
the his-
ances of
roaching
on.....
ccount of
teamship
n cables,
—1 illus-
ighly in-
class of
M.D.—A
letails of
experi-
ow.—3 il-
.—An in-
ntly read
es in this
—By J. S.
r at the

ooks

Engineers,
rofessional
ne of their
nt permits
ils at very
eful books
ferent sub-
irculation,
ified with
have only
Address,
ew York.

merican,
rican and
ience, and
he world.

e Ameri-
s Agency,
e. By the
tention is
d sales or

or inven-
a patent
NN & Co.
he Patent
costs, and

York.